COMMISSION OF INQUIRY INTO THE AIR ONTARIO CRASH AT DRYDEN, ONTARIO

Final Report

Volume I

The Honourable Virgil P. Moshansky
Commissioner

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This Final Report consists of three volumes: I (Parts One–Four), II (Part Five), and III (Parts Six–Nine and the General Appendices). The table of contents in each volume is complete for that volume and abbreviated for the other two volumes. Seven specialist studies prepared for this Commission have been published separately in a volume entitled Technical Appendices; the contents of the Technical Appendices are given at the end of this volume.

CANADA

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This volume has been translated by the translation services of the Secretary of State, Canada, and is available in French.

The aerial photograph reproduced in the endpapers was taken by CASB investigators on March 11, 1989, the day following the crash of Air Ontario flight 1363. It depicts the area of the Dryden Municipal Airport (upper right), surrounding road system, and crash site. McArthur Road runs vertically up the middle of the photograph, curving to the right at about the centre of the book on the right-hand page. (The cleared straight line is a hydro right of way.) Middle Marker Road angles to the left off McArthur in the lower left-hand section. The path of Air Ontario flight 1363 through the trees begins not far from the end of runway 29, and the crash site can be seen just above Middle Marker Road. Many survivors walked out to Middle Marker Road immediately after the crash.

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Commission of Inquiry
into the Air Ontario Crash
at Dryden, Ontario

CANADA

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sur l'écrasement d'un avion
d'Air Ontario à Dryden (Ontario)

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TO HIS EXCELLENCY
THE GOVERNOR GENERAL IN COUNCIL

MAY IT PLEASE YOUR EXCELLENCY

By Order in Council PC 1989-532 dated the 29th of March, 1989, I was appointed Commissioner to inquire into the contributing factors and causes of the crash of Air Ontario Flight 1363 Fokker F-28 at Dryden, Ontario, on March 10, 1989, and report thereon, including such recommendations as I may deem appropriate in the interests of aviation safety.

Having previously submitted two Interim Reports, I now beg to submit my Final Report consisting of four volumes in each official language.

Respectfully submitted.

Commissioner

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PREFACE

This Report is the product of an exhaustive investigation not only of the crash of Air Ontario flight 1363, which occurred at Dryden, Ontario, on March 10, 1989, but also of the aviation system that allowed it to occur. It should be considered in conjunction with my two *Interim Reports*, which were released in December 1989 and December 1990, respectively.

My Commission staff, in the course of their investigation of the Air Ontario accident at Dryden, interviewed hundreds of potential witnesses and reviewed thousands of potential documentary exhibits. In the end the witness list was pared to 166 witnesses who were called to testify, and the exhibits were reduced to 1343 in number, most of them being documents, many containing hundreds of pages. Evidence was taken under oath in a public forum, subject to cross-examination, for a total of 168 hearing days. This Report is a synthesis of both the testimony of those 166 witnesses, contained in 168 volumes of transcript totalling some 34,000 pages, and of the contents of the documentary exhibits totalling more than 177,000 pages.

The public hearings of this Commission, held in Dryden, Thunder Bay, and Toronto over a period of 20 months, from June 1989 to January 1991 inclusive, disclosed numerous safety-related deficiencies and failings within the carrier, Air Ontario, specifically; within the aviation industry generally; and in the regulatory domain of Transport Canada. These shortcomings, their causes, and their relationship to the accident at Dryden were closely scrutinized during the hearings. They are addressed in detail in this Report, and, in accordance with the mandate given to me, recommendations for change are made.

Pursuant to an agreement reached with the chief coroner for the Province of Ontario, I conducted an investigation, during the hearings of my Commission, into matters that would normally fall within the jurisdiction of the chief coroner for Ontario. As a result of this arrangement, a substantial duplication of effort was avoided. The chief coroner for Ontario at the time,Dr Ross Bennett, and his successor, Dr James Young, shared my concern that there be an in-depth analysis of the human performance aspects of the accident at Dryden. In lieu of holding a coroner's inquest, the chief coroner for Ontario was granted full participant status in the Inquiry. I am grateful for the chief coroner's unreserved cooperation and assistance in this endeavour and for his written advice that the goals of the Office of the Chief Coroner for the Province of Ontario have been fully met by this Commission (attached as appendix F).

The Inquiry process afforded a good opportunity for the identification in a public forum of aviation safety problems within the aviation industry generally and within Air Ontario specifically. Accordingly, with respect to the air carrier, a searching investigation was conducted, not only into Air Ontario's F-28 program but also into virtually every aspect of the operations of Air Ontario, beginning with its corporate history and culminating with its management policies and practices and its relationship with its parent company, Air Canada.

In the case of the regulator, Transport Canada, this Inquiry was the vehicle for a constructive public examination of the inner workings of the Aviation Group of that department. This examination was described by the current assistant deputy minister of transport, aviation, Mr David Wightman, as probably "the most in-depth look at the operations of Transport Canada, the Aviation Group, and the Regulatory side of it specifically, that we've ever had." He further commented on the witness stand with respect to the process of this Inquiry that: "It has been an exceptionally valuable learning experience for me. I assure you." Similar sentiments, which were expressed by numerous other witnesses and by the many members of the Canadian public who communicated directly with me, have reinforced my strong belief in the value of a public Inquiry under the *Inquiries Act*. As a means of conducting an investigation – in this case, that of a major aviation accident – such an Inquiry under the *Inquiries Act* has the great advantages of virtually unlimited power to subpoena witnesses and the testing of their evidence in the crucible of cross-examination. I am convinced that, as an instrument in the search for truth, a public Inquiry, judiciously and fairly conducted, has no peer.

This Report is based exclusively on the extensive evidentiary record that has been assembled. The integrity of the evidentiary record was dependent upon the procedures that were adopted for the conduct of this Inquiry.

As discussed in my first *Interim Report*, on the first day of the public hearings of this Commission, May 26, 1989, I granted full participant status, special participant status, and observer status, respectively, to various parties. Subsequently during the hearings, other parties were granted status for limited purposes only. All parties granted status are listed in appendix C. On May 26, 1989, I stated my intention that the concept of procedural fairness would be the basic tenet of this Inquiry, and I made the following statement with respect to the rights which would be accorded to all parties granted full participant status before the Commission:

> Parties who are granted the status of a full participant will be permitted representation by counsel. Their counsel will be able to

> cross-examine Commission witnesses, submit written briefs to the Commission and, if necessary, to recommend to the Commissioner the calling of certain witnesses.
>
> In the course of any commission of inquiry, allegations will be made at public hearings which will reflect adversely on certain parties. It is my position that any party adversely implicated by testimony at the public hearings of the Commission shall be given a full opportunity to be heard.
>
> (Transcript, vol. 1, p. 9)

Similar rights were accorded the representative counsel granted special participant status on behalf of the survivors and the families of victims of the crash of flight 1363. It was my intention from the outset that the process of this Inquiry would, in the interests of fairness to those who might be affected by the process, mirror as closely as possible the proceedings of a court of law.

On the second day of the public hearings I elaborated upon the procedures that would govern the conduct of the proceedings of this Commission as follows:

> I will now deal with the question of the procedures which I propose to be followed during the hearings of this Commission. It is intended that the procedures will be those already outlined by me at the status hearings and as amplified by correspondence from Commission counsel, Mr von Veh, to the interested parties dated June 2, 1989.

In addition, I propose that the following rules of procedure will apply:

- Firstly, with respect to **Opinion Evidence**, the Commission will only receive opinion evidence of a witness where it is indicated that the witness possesses a special skill by reason of experience or study in respect of the particular subjects on which he or she intends to express an opinion.
- Secondly, with respect to **Rebuttal Evidence**, the Commission at its discretion may allow reply evidence to rebut evidence given by another witness or witnesses, such evidence to be limited exclusively to rebuttal.
- Thirdly, Commission counsel shall have discretion to select one or more persons from among a group of persons who have similar evidence to give on a matter under consideration, to give such evidence for the benefit of the persons having similar evidence.
- Fourthly, while recognizing that a commission of inquiry has a somewhat different role than a court of law and that evidentiary and procedural rules applicable in a court of law are not necessarily automatically applicable to a commission of inquiry,

it is my intention, in the interests of fairness, that the inquiry hearings shall be conducted in such a manner so as to adhere as closely as possible to the commonly accepted evidentiary rules as to relevance, to the admission of hearsay evidence, and as to the putting of leading questions to witnesses.

- Fifthly, every party shall have the right to cross-examine any witness whom he or she believes to be in error or to be suppressing facts. This right is not to be abused by irrelevant or repetitive questioning.
- Sixthly, the Commissioner, in the absence of agreement between counsel, will determine the order in which counsel for the participants will be entitled to cross-examine witnesses.

(Transcript, vol. 2, pp. 51–53)

In addition to the adoption of these procedures (which were outlined previously in my first *Interim Report*), the following specific procedures were implemented to give practical effect to the proposition that any individual who might be adversely implicated before this Commission had the full right to be heard:

- Virtually all interviews undertaken by Commission staff of potential witnesses who were affiliated with any of the parties granted full participant status were conducted in the presence of counsel. In all cases when a prospective witness or his or her counsel requested copies of interview transcripts, such were promptly provided by Commission staff.
- Before any witness testified, synopses of the anticipated testimony of all witnesses intended to be called, based on preliminary witness interviews by Commission staff, were forwarded to all participating parties.
- Before any witness testified, photocopies of all exhibits proposed to be introduced through a given witness were forwarded to all participating parties.
- All counsel appearing before the Commission were afforded broad rights of cross-examination of all witnesses.
- All participating parties were afforded the right to file written briefs as they saw fit, for my consideration.
- All hearings were conducted in such a manner so as to adhere as closely as possible to commonly accepted evidentiary rules.
- All counsel appearing before me were afforded the opportunity to call such further evidence as they saw fit.
- All counsel appearing before me were afforded the opportunity to present closing arguments.

To the extent that any party perceived that there were any inaccuracies or misstatements by any witness on the record, that party, directly or through counsel, was able to take steps to clarify the record – by

cross-examining a witness, by adducing new evidence, or by submitting oral or written argument to me. Throughout this process, all parties availed themselves of these rights from time to time as they saw fit.

The mandate of this Commission was to investigate a specific air crash and to make recommendations in the interests of aviation safety. In carrying out this mandate, it was necessary to conduct a critical analysis of the aircraft crew, of Air Ontario Inc., of Transport Canada, and of the environment in which these elements interacted. As will be explained in the Introduction, I have adopted a system-analysis approach, with emphasis on an examination of human performance.

Following the completion of the hearings of this Inquiry, in late January 1991, my staff and I began reviewing both the voluminous transcripts of evidence and the great mass of documentary exhibits, prior to commencement of the task of writing this Report. This preliminary work was completed in March 1991. At that time my counsel staff and technical advisers were assigned to several research teams charged with the responsibility of preparing draft material in specific areas, according to their expertise and interests. I was personally involved with each such team, meeting regularly with team members and directing the course that I wished to be taken by the researchers. The enormous amount of evidentiary material that had to be reviewed and distilled into this Report, and the severe time constraints imposed for its production, required a dedicated team effort. The various drafts of every chapter of this Report were subjected by me to numerous reviews and revisions. My writing of this Report was basically completed in early November 1991, approximately seven months after the initial drafting began.

This Final Report consists of nine Parts (divided into 44 chapters) and general appendices in volumes I, II, and III, and a separate volume of seven Technical Appendices. Part One sets out the terms of reference for this Commission and includes a description of the duties imposed upon me by Order in Council and a description of the system-analysis approach of accident investigation utilized by this Commission of Inquiry. This Part includes a brief description of the air transportation system components pertinent to the crash of Air Ontario flight 1363, namely:

- the aircraft, C-FONF
- the aircraft crew of C-FONF
- the operational environment affecting the flight crew
- the air carrier, Air Ontario
- the regulator, Transport Canada.

Part Two of the Report includes synopses of the facts leading to the crash of Air Ontario flight 1363, of the crash itself, and of the Dryden

area response to the crash. Part Three deals with an important area in the context of airline passenger safety: the airport crash, fire-fighting, and rescue services. This issue was thoroughly examined during the hearings.

Part Four describes the technical investigation of the accident and deals with the issue of crash survivability and the highly technical areas of aircraft performance and flight dynamics.

Part Five represents an in-depth examination of Air Ontario's history: the carrier's corporate mergers and management organization, and its program for the acquisition, implementation, and operation of F-28 aircraft. Numerous shortcomings in the F-28 program, discovered during this Inquiry, are dealt with in detail in the eight chapters devoted to this subject. This Part concludes with an assessment of Air Ontario management performance and of the role of the parent corporation, Air Canada.

Part Six of this Report is the product of an intensive examination by this Commission of the role of the regulator, Transport Canada, in assuring a safe air transportation system generally and a safe operation by Air Ontario specifically. The results of this examination were such that Transport Canada was found wanting in a number of areas critical to aviation safety. I thought it insufficient simply to expose regulatory shortcomings without discovering the reason for their existence. In this Part, I examine in considerable detail the effects upon aviation safety of the policy of economic regulatory reform (ERR), which was put in place in conjunction with a concurrent governmental policy of fiscal restraint. As well, the performance of senior Transport Canada management in responding to the resource needs of its front-line air carrier inspectors is critically assessed. This Part also specifically assesses how Transport Canada discharges its responsibilities in the areas of aviation regulation and legislation, air carrier audits, monitoring and surveillance, operating rules and legislation, company check pilots, spot-checks, and safety management, to list a few.

Part Seven contains a systemic analysis of the human performance aspects of this accident. The flight crew of Air Ontario flight 1363 erred in deciding to commence the takeoff at Dryden with contaminated wings. The finding of human error on the part of the flight crew is the reason for an analysis of the human performance aspects of this crash. If effective preventive measures are to be found, then the reasons for and the underlying causes of the human error must be fully understood. This Part, which represents a synthesis of the findings of the entire investigation of this accident, is a departure from the usual format for aviation accident investigations in that the role of air carrier management in the events leading to a breakdown in the air transportation system is closely scrutinized. I was greatly assisted in this area by those internationally

recognized experts in the field of human performance who were special advisers to this Commission.

Part Eight represents my analysis, views, and recommendations with respect to certain legal and other issues concerning the aviation accident investigation process in Canada; the reporting of aviation incidents and accidents and the issue of pilot confidentiality; the matter of the objection to production of documents based on a confidence of the Queen's Privy Council, pursuant to section 39 of the *Canada Evidence Act*, R.S.C. 1985, c.C-5; and the matter of section 13 of the *Inquiries Act*, R.S.C. 1985, c.I-11.

In the later stages of the preparation of my Final Report it became clear that I would be making comments which might be perceived to be adverse to certain individuals. Section 13 of the *Inquiries Act* requires that reasonable notice be given to a person against whom a charge of misconduct is alleged in a report and that the person be allowed full opportunity to be heard in person or by counsel. Although my intended comments did not, in my view, constitute a "charge of misconduct" against any individual within the meaning of section 13 of the *Inquiries Act*, in the interests of fairness I instructed Commission counsel to send written notice to all of these individuals, advising of the substance of the intended adverse findings and inviting them to make written or oral submissions to me in response thereto. Such notices were delivered in the latter part of August 1991. In a number of instances individuals responded to the notice given to them under section 13. In all instances, the responses were carefully considered by me. The procedures adopted by this Commission with respect to section 13 of the *Inquiries Act*, the provisions of section 13 itself, and the proceedings brought by Air Ontario and certain unnamed individuals in the Federal Court of Appeal, after receipt of notice under section 13, and the subsequent withdrawal of those proceedings are discussed in Part 8 of this Report.

I have made numerous recommendations in my first and second *Interim Reports* and throughout the body of this Final Report. All these recommendations are consolidated in Part Nine for the convenience of readers. During the course of the Inquiry I was called upon to make a number of rulings involving points of law or procedure. These rulings are reproduced as appendix M among the general appendices to this Report. The volume of Technical Appendices is published to disseminate specialized research gathered by the Commission.

This Report is, in certain instances, critical of individuals and institutions where criticism, in my view, is warranted. Such criticism is an unavoidable result flowing from the nature of this Inquiry and the evidence. It is intended to be constructive, the objective being the prevention of similar accidents in the future. At the same time, acknowledgement is made in the Report of aviation safety–related improvements

that have already been made by the air carriers and by the regulator, Transport Canada, to the aviation system, in response to deficiencies discovered in the course of the hearings. In particular, the air carriers and Transport Canada are commended for the implementation of new inspection and de-icing procedures at Pearson International Airport in Toronto during weather conditions when aircraft surface contamination due to freezing rain, snow, and ice is likely. The recently announced intention of Transport Canada to construct at Pearson a remote touch-up de-icing spray facility and a major de-icing/anti-icing facility with provision for fluid recycling, estimated to cost $45 million, is a welcome response to the safety concerns and recommendations outlined in my *Second Interim Report*.

What was also discovered during the hearings was the fact that, generally speaking, Transport Canada is staffed at all levels by competent and dedicated persons who are sincerely doing their best to ensure a safe air transportation system for the public, at times under trying and frustrating circumstances.

The many air carrier pilots and others involved in the aviation industry who testified before this Inquiry impressed me with their general professionalism and with their commitment to aviation safety. I must mention in particular the valuable contribution of the Canadian Air Line Pilots Association throughout the investigative stage and the hearings of this Inquiry.

It is my hope that the work of this Commission will have served as a catalyst for change. In my view, one of the lasting benefits from this Inquiry is to be found in the greatly heightened awareness that has been generated not only among those involved in the aviation industry, but also among the members of the public, in matters of aviation safety generally, and particularly as to the dangers presented by aircraft surface contamination and the need to ensure clean wings on takeoff. The Canadian media deserve a great deal of credit for this heightened public awareness. There can be no doubt that the widespread and responsible coverage of the public hearings of this Commission by members of the media has had a beneficial effect.

I am confident that, if the contents of this Report are carefully considered and the recommendations made herein are accepted and implemented in a timely manner, an important contribution to aviation safety in Canada will have been made.

The readers of this Final Report should view the critical nature of the analysis contained in it as this Commission's contribution towards enhancing the safety of the travelling public. Transport Canada and the Canadian aviation industry will ultimately have to strike the delicate balance between maintaining an adequate level of aviation safety and dealing with realistic economic considerations.

ACKNOWLEDGEMENTS

This Report could not have been written without the help of a great many people. I am grateful to all of my counsel and my technical staff for joining me in working, without respite, through the summer and fall of 1991 to complete an enormous task in the shortest time possible. They have earned my deep respect.

I believe it to have been a distinct advantage that virtually everyone involved in an official capacity with this Commission had an aviation background, either in the military or in civil aviation, or in both. The result was a compatible working group, knowledgeable in aviation matters, possessing an understanding of the principles of flight and a command of the terminology and the language of aviation.

No Commission can function effectively without the assistance of a highly competent, dedicated, and motivated Commission counsel. I was most fortunate to have such a counsel in the person of Mr Frederick von Veh, QC, of Toronto. A veteran of several Commissions of Inquiry, Mr von Veh's previous Commission experience and his background in administrative and transportation law proved invaluable to me not only in the initial organization and staffing of this Commission, in the assembly of my Commission team of investigators and technical experts, and in the prompt startup of the Commission process, but also throughout the conduct of this Inquiry. In addition to being deeply involved in the planning of the basic direction that the Inquiry was to take, Mr von Veh had the heavy responsibility of organizing and overseeing the work of my entire Commission staff throughout the life of this Commission. He also very ably served as counsel during a number of important phases of the hearings of this Inquiry. Upon the conclusion of the hearings he assisted me greatly in the onerous day-to-day management of the research, drafting, and revision activities for this Final Report. His drive and perseverance contributed much to its timely production. He was also responsible for all matters pertaining to section 13 of the *Inquiries Act*. Mr von Veh has discharged his multiple and weighty responsibilities as Commission counsel in a most professional manner. I am greatly indebted to him.

I was very well served also by my associate Commission counsel, Mr Gregory L. Wells of Calgary. His experience and unique background as a former military pilot, as an air carrier pilot, and as a counsel involved in aviation law enabled him to make a very important contribution to this Inquiry. Mr Wells did much of the counsel work at the Inquiry hearings, acquitting himself admirably. He was heavily involved in the

research and draft writing of the highly technical sections of this Report, and he participated in the numerous reviews of its various sections. I am most appreciative of the total commitment that he made to the work of this Commission and for the thorough and professional job that he has done.

The other members of my counsel staff, Mr Adam Albright, Mr William Cottick, Mr Laurence Goldberg, Mr William McIntosh, and Mr Douglas Worndl, all worked very hard throughout the investigative phase, the hearings phase – during which they appeared as counsel – and the research and report-writing phase of this Inquiry. I thank them for their dedication and tireless efforts. Mr Worndl, who has been a member of my counsel staff from the inception of this Commission, was my director of research. He assisted me in the drafting, revising, and refining of many of the sections of this Report and has rendered exemplary service to this Commission.

I wish to express my appreciation also to my outside counsel, Mr Ian Binnie and Mr Peter Griffin of Toronto, for their advice and counsel at various times and for so capably representing me in the Federal Court of Appeal proceedings taken under section 13 of the *Inquiries Act*.

The investigation of an aviation accident requires specialized investigation teams under the direction of an experienced and knowledgeable team leader. It was my good fortune to obtain the secondment to my Commission, from the Canadian Aviation Safety Board (now the Transportation Safety Board of Canada), of an outstanding aviation accident investigator, Mr Joseph Jackson of Ottawa, for the position of investigator in charge. I express my deep appreciation to him and to his corps of investigators for their total dedication to this investigation. Mr Jackson, a skilled writer, was also involved in the research and preparation of drafts of several highly technical sections of this Report and made important contributions to other areas of this Report.

My senior technical adviser, Mr Frank Black of Manotick, Ontario, a private aviation consultant and the former chief of aeronautical licensing for Transport Canada, was the driving force behind the complex and difficult Transport Canada phase of the Inquiry. As well, Mr Black assisted me greatly in the aircraft ground de-icing/anti-icing phase that culminated in my *Second Interim Report*. He was ably assisted by Mr James Fitzsimmons, a former regional director of aviation regulation, Ontario Region, for Transport Canada, and both were instrumental in the research and preparation of drafts of the Transport Canada sections of this Report. In addition, Mr Black, along with Mr Jackson and Mr Worndl, assisted me greatly in the drafting of the Human Performance chapter of this Report. I am grateful to Mr Black for his sage advice and counsel.

My technical advisers, Captain Robert MacWilliam, Mr David Rohrer, Mr David Adams, and Mr Reg Lanthier, made important contributions throughout the investigative and hearing phases of the Inquiry, with Captain MacWilliam also being involved in research and drafting of the various operational chapters and the Human Performance chapter of this Report and as a valued adviser during the Final Report review committee meetings.

My special advisers, internationally known in the field of aviation accident investigation, Dr Charles O. Miller, Mr Gerard Bruggink, and Dr Robert Helmreich, gave me the benefit of their expert knowledge and experience in aviation accident investigation both throughout the investigative and the hearing stages of this Commission and in their critiques of various drafts of this Report. It was a great privilege to associate and work with such outstanding individuals.

My thanks go to Detective Inspector Dennis Olinyk and Detective Sergeant Donald MacNeil of the Ontario Provincial Police and to those other members of the force who were seconded to this Commission as full-time investigators and served so diligently and professionally. My thanks also to the communications adviser for the Commission, Mr Gordon Haugh, for his ongoing rapport with all branches of the media and for his research and contributions to the section on the Dryden area response to the crash.

On the administrative side I wish to express my appreciation to Commission administrator Mr Robert McBey, also a veteran of previous Commissions and a former military pilot, who assumed the position early in the life of this Commission and has skilfully guided the administrative and financial side of the Commission to an under-budget conclusion. He has been ably assisted by Mrs Sylvia Cannon, assistant administrator to the Commission. My thanks also to Mr William Pratt, assistant deputy minister of management services; to Ms Hélène Langlois, Commission coordinator; and to Mr Peter Brennae of the Inquiries Secretariat, Transport Canada, for their valued advice and assistance so willingly given.

The Commission registrars, Mr Norman Savage and his successor Mr Sidney Smith, and the hearing room officers, Mrs Karen Roche, Mr William Channon, and Mr Ernest Garnham, contributed much to the decorum and orderly conduct of the hearings. For their dedication and valuable service beyond the call of duty I express my sincere appreciation to the Commission records and exhibits manager, Mr Clifford Collier, to his assistant, Mr Christopher Perkins, and to the secretarial, clerical, and computer operations members of the Commission office staff: Pauline Cheeks, Roberta Grant, Mitchell Klein, Louise Madore-Payer, Margaret Mason, Elizabeth Nagata, Savita Patil, Sonja Thomason, Jenifer Williams, and my personal secretary Arlene Walker. I also

express my appreciation to other members of my secretarial and clerical staff who served the Commission most diligently for shorter periods of time: Joe Anile, Sheila Brown, Lisa Buxton, Florence Guttierez, Janet Hinton, Debbie McBurnie, Patricia McIntosh, Sheila Moore, and Diane Risteen.

I wish also to acknowledge the outstanding contribution made to the Inquiry by all of the counsel who represented interested parties throughout the hearings of this Commission. A large number of these counsel also had backgrounds in aviation. All of them acquitted themselves in an exemplary manner, and I hesitate to single out any one of them for specific mention. However, I feel that I should acknowledge the outstanding service rendered by Mr Paul Bailey, counsel to the chief coroner for Ontario. Mr Bailey bore the brunt of the cross-examination of witnesses, and his efforts have in fact been acknowledged by his own peers. He also made an important contribution in his reviewing, on behalf of the chief coroner, of certain draft sections of this Report, for which I offer my thanks. In addition, I will also mention Mr Kristopher H. Knutsen and Mr S. Alexander Zaitzeff, who ably represented the survivors and the families of victims of the Dryden crash as a result of my decision to grant to this group unprecedented special participant status.

Those parties who were granted full participant status, and who seconded to the various investigative groups of this Commission highly experienced experts as participants, are to be commended for the valuable contributions that they made to the process of this Inquiry. I acknowledge the cooperation of the counsel for and the officials of Transport Canada with the officials of my Commission, and I express my appreciation to the assistant deputy minister of transport for his direction to all Transport Canada officials who appeared before this Commission that they were to do so freely and with no sense of inhibition.

Crucial to the writing of a report of this nature are the services of professional editors. It has been my good fortune to have secured the services of three of the best, Mary McDougall Maude, Rosemary Shipton, and Daniel Liebman. They have been involved since the early stages of the writing of this Report and have given to me and my staff the benefit of their valuable advice and guidance. Besides carrying out their editorial work, they have also acted as the liaison between the Commission and the translators and printers, and they have looked after the myriad of details involved in the publication of this Report. I express to them my thanks for the total dedication that they have brought to this task and for their consummate professionalism. My appreciation and thanks are extended as well to the editors of the French edition, Mrs Margot Côté and Mr Paul Ollivier, QC.

Finally, I wish to thank all of the witnesses who testified, including the many expert witnesses, for their valuable contribution to this Inquiry. To the many pilots from across the country and the numerous members of the public who have personally contacted me or who have written to me with expressions of interest, suggestions, and encouragement during the life of this Commission, I express my sincere appreciation for their interest. On a personal note, to my wife June, for her understanding and tolerance of my prolonged absences from home, my thanks.

GLOSSARY OF TERMS AND ACRONYMS

Symbols and Units of Measure

°	degree(s) – applies to latitude and longitude
′	minute(s) – applies to latitude and longitude
″	second(s) – applies to latitude and longitude
BTU	British Thermal Unit
fpm	feet per minute
G *or* **g**	a symbol used to denote the force of gravity (load factor)
in Hg	inches of mercury
KHz	kilohertz
knot	a nautical mile per hour or 1.15 statute miles per hour
°M	degrees magnetic
mb	millibar(s)
MHz	megahertz
pph	pounds per hour
psi	pounds per square inch
rpm	revolutions per minute
°T	degrees true

Glossary of Terms and Acronyms

The terms and acronyms contained herein are general in nature and are not intended to provide complete and/or technical definitions. Rather, they are included as references to assist the reader. Many of the terms and acronyms are more completely defined and described in specific sections of this Report.

AAG	Transport Canada Airports Authority Group
A-base review	A systemic review of the Canadian Air Transport Administration, initiated in November 1982 for the purpose of determining an appropriate level of resources
above ground level	Height measured from the surface of the earth
AC	Air Canada
ACA	Aircraft certification authority
ACC	Area control centre (air traffic control)
accelerate stop distance available	The length of takeoff run available plus the length of stopway if provided
accident	An aviation occurrence in which: (a) a person sustains a serious or fatal injury; (b) the aircraft sustains damage or failure normally requiring major repair (with exceptions); or (c) the aircraft is missing or completely inaccessible
ACM	Air cycle machine
ACN	Aircraft classification number (ICAO)
AD	*See* airworthiness directive
ADF	Automatic direction finder
adiabatic cooling	The process by which air is cooled solely through expansion as it ascends

ADM	Assistant deputy minister
ADMA	Assistant deputy minister, aviation
ADMR	Assistant deputy minister, review
AEA	Association of European Airlines
aerodrome	Any area of land or water designed, prepared, and equipped for use in arrival and departure or servicing of aircraft. The aerodrome includes all runways and taxiways and any buildings and fixed equipment.
Aeronautical Information Publication	A document produced by Transport Canada to provide pilots with a single source of information concerning rules of the air and procedures for aircraft operations in Canada
AES	Atmospheric Environment Service
AFM	*See* aircraft flight manual
A/G	Air/ground
agl	*See* above ground level
AIC	Aeronautical information circular
ailerons	Pairs of control surfaces, normally hinged along the wing span, designed to control an aircraft in roll
A.I.P.	*See* Aeronautical Information Publication
air bottle	A device used to store air under pressure for use in producing rotation in a jet engine for starting

air brake	A device attached to an aircraft for the purpose of reducing lift and/or increasing drag while the aircraft is airborne. It is normally controlled by the pilot and used in flight to reduce air speed or increase the rate of descent. Also referred to as speed brake.
air carrier	Any person or organization operating a commercial air service
Aircraft Flight Manual	Sometimes referred to as flight manual/flight handbook. It sets out operating limitations, emergency procedures, abnormal procedures, normal operating procedures, and flight and ground-handling and performance data. Produced by the aircraft manufacturer, the Aircraft Flight Manual forms part of the type certification of the aircraft.
Aircraft Operating Manual	Sometimes referred to as a flight manual or standard operating procedures (SOPs) manual. It is developed by the carrier to set out standard operating procedures for a specific aircraft type. It is based on and is no less restrictive than the approved Aircraft Flight Manual. Examples are the Piedmont Airlines F-28 Operations Manual and the USAir F-28 Pilot's Handbook.
Aircraft Operations Groups Association	The bargaining agent that represents Transport Canada civil aviation inspectors
airflow	Movement of air around a moving object. Airflow generally refers to a moving aircraft.
airfoil	A structure designed to produce a useful reaction of itself in its motion through the air. It generally refers to an aircraft wing.
airframe	The assembled structural and aerodynamic components of an aircraft

airline transport rating — A certificate of competency issued by Transport Canada to a pilot meeting the requirements. This is the highest rating available in Canada to a commercial pilot.

Air Navigation Order — An order having the force of law that finds its origins in the *Aeronautics Act* and the Air Regulations

airport — An aerodrome that has been inspected by Transport Canada inspectors, has met specific standards, and has been issued an aerodrome certificate

airport surveillance radar — A relatively short-range radar intended primarily for surveillance of airport and terminal areas

air route — A prescribed track between specified radio aids to navigation, along which air traffic control service is not provided

air traffic control clearance — Authorization by an air traffic control unit for an aircraft to proceed within controlled airspace under specified conditions

air traffic control instruction — A directive issued by an air traffic control unit for air traffic control purposes

air start unit — A machine that provides pressurized air to a jet engine for the purpose of starting it

airway — A prescribed track between specified radio aids to navigation in controlled airspace

airworthiness — In respect of an aeronautical product, being in a fit and safe state for flight and in conformity with applicable standards

airworthiness directive — Instruction that specifies the modification, replacement, or special inspection required to preserve the continuing airworthiness of an aircraft

alternate airport	An aerodrome specified in an IFR flight plan to which a flight may proceed when a landing at the intended destination becomes inadvisable
altimeter	An instrument that uses barometric pressure to measure height above a reference datum
AME	Aircraft maintenance engineer
AMO	Approved maintenance organization
angle of attack	The angle between the chord line of an airfoil and the relative airflow
ANO	*See* Air Navigation Order
ANS	The national Air Navigation System
anti-ice	Prevention of the buildup of ice
anti-skid	With reference to braking, a system that provides for maximum brake effectiveness by not allowing the wheels to stop turning completely
AOGA	*See* Aircraft Operations Groups Association
AOM	*See* Aircraft Operating Manual
APM	Airport manager
APU	*See* auxiliary power unit
aquaplane	*See* hydroplane
ARASS	*See* aviation regulation activity standards system
ASDA	*See* accelerate stop distance available
ASE	Aviation safety engineering
asl	Above sea level, height in feet measured from sea level

ASP	Aviation safety programs
ASR	*See* airport surveillance radar
ATAC	Air Transport Association of Canada
ATC	Air traffic control
ATF	Aerodrome traffic frequency
ATIS	Automatic terminal information service
ATPL	Airline transport pilot licence (replaces ATR)
ATR	Airline transport rating
ATS	Air traffic services
ATZ	Aerodrome traffic zone
audit (regulatory)	An in-depth review of the activities and facilities of an organization such as an air carrier or a manufacturing, repair, or overhaul facility to verify conformance with regulatory standards and practices
audit manager	An individual, designated by the convening authority, who is responsible for planning and overall conduct of the audit, up to and including the production of the final audit report
automatic direction finder	A radio direction finder that automatically and continuously provides an indication of the direction to a tuned radio beacon
automatic terminal information service	The continuous broadcast of recorded non-control information in selected busy terminal areas
autopilot	Equipment that automatically controls an aircraft as directed by the pilot(s)
autothrottle	Equipment that automatically adjusts aircraft power to maintain a selected airspeed

auxiliary power unit	A small turbine engine installed in some aircraft to provide pressurized air and electrical power
aviation regulation activity standards system	A staffing standard developed by and used within Transport Canada's Aviation Group
AWIS	Aviation weather information service
BASI	Australian Bureau of Aviation Safety Investigation
bleed air	Air taken from the compressor section of a turbine engine, used to operate some aircraft systems
button	The point on a runway in the immediate vicinity of the threshold from which takeoff normally begins
C	The symbol added to designators of Canadian airports for international flights
CA	*See* convening authority
CADORS	Civil aviation daily occurrence reporting system
CAF	Canadian Armed Forces
CAI	Civil aviation inspector
CALDA	Canadian Air Line Dispatchers Association
CALPA	Canadian Air Line Pilots Association
CAMU	Civil aviation medical unit
CAP	*Canada Air Pilot*, a Transport Canada publication depicting instrument approach procedure at Canadian airports. Operating weather minima are given for each airport.

CASB	Canadian Aviation Safety Board
CAT	Clear air turbulence
CATCA	Canadian Air Traffic Controllers Association
CCFR	Chief, crash, fire-fighting, and rescue services
CCI	Condition conformity inspection
CCP	*See* company (carrier) check pilot
CDL	(1) Central datum line; (2) configuration deviation list
ceiling	The lowest height above ground at which a broken or overcast sky condition exists
centre line	A line running the length of a runway, depicting the centre
certificate of airworthiness	A conditional certificate of fitness for flight, issued in respect of a particular aircraft under the Air Regulations or under the laws of the state in which the aircraft is registered
certificate of registration	A certificate issued to an aircraft owner when the aircraft is registered under the Air Regulations
certification	The process of determining competence, qualification, or quality on which issuance of a Canadian aviation document is based, in accordance with the procedures approved by the minister. This process includes original issuance, denial renewal, or revision of that document.
C/F	Carried forward
CFB	Canadian Forces Base
CFR	Crash, fire-fighting, and rescue (services); crash fire rescue (services)

CFS	*Canada Flight Supplement*, a Transport Canada publication that provides aerodrome and related information for use during flight planning and in flight
checklist	A consolidation, in checklist form for ready reference, of the procedures and limited essential information set out in the Aircraft Operating Manual
checkout	Attaining individual competency in a specific aircraft
check pilot	A pilot appointed by an airline to carry out competency evaluations on company pilots
chief pilot	In the case of Air Navigation Order Series VII, No. 2, a management position required of an air carrier. Air carriers operating a number of large aircraft may have a chief pilot for each aircraft type.
chord	A datum line connecting the leading and trailing edges of an airfoil, and from which the angles of the airfoil are measured
circuit	A rectangular pattern flown by an aircraft from takeoff to landing
clearance (air traffic control)	Authorization by an air traffic control unit for an aircraft to proceed within controlled airspace under specified conditions
clearway	A defined rectangular area over the ground, selected or prepared as a suitable area over which an aircraft may make a portion of its initial climb to a specified height
cockpit (or crew) resource management	The enhancement of air crew knowledge, management skills, and attitudes to promote effective management of all available resources, both human and technical, to maintain a safe flying operation

cockpit voice recorder	A recording device used to record all sounds in the cockpit during flight, including all transmissions and receptions on the radios
coefficient of lift (C_L)	Dimensionless measure of aerodynamic lift, where lift is the aerodynamic force generated perpendicular to the relative airflow. Expressed as aerodynamic lift force divided by the product of the free stream dynamic pressure and the surface area. $$C_l = \frac{L}{\frac{1}{2}\rho V^2 S}$$ Free stream dynamic pressure = $\frac{1}{2}\rho V^2$ where L = lift, ρ = air density, V = velocity, S = surface area
C of A	*See* certificate of airworthiness
C of G	Centre of gravity
C of R	*See* certificate of registration
cold soaking	The process which occurs when an aircraft is subjected to cold temperatures so that all or part of the aircraft is cooled to ambient temperature
company (carrier) check pilot	A check pilot employed by an air carrier who has delegated authority to carry out certain check pilot functions on behalf of Transport Canada
confirmation request form	The form issued to the auditee by a TCAG inspector requesting information that was not readily available. The auditee must respond within a specified time period.
conformance	The state of meeting the requirements of a standard, a specification, or a regulation

controlled airspace	Airspace of defined dimensions within which air traffic control service is provided
controlled VFR (CVFR) flight	A flight conducted under the visual flight rules within Class B airspace surrounding an airport and in accordance with an air traffic control clearance
control zone	Controlled airspace of defined dimensions extending upwards from the surface of the earth up to 3000 feet above the airport elevation, unless otherwise specified
convening authority	The manager within Transport Canada Aviation Regulation responsible for authorizing a regulatory audit
COPA	Canadian Owners and Pilots Association
Corrective Action Plan	A plan submitted to the convening authority or his or her delegate by the auditee, following receipt of the audit report. This plan details the action to be taken to correct the deficiencies identified by the audit findings. It is intended to bring the auditee into full conformance with regulatory standards.
CRFAA (CRFFAA)	Critical rescue and fire-fighting access area
CRM	*See* cockpit (or crew) resource management
cross-country (flight)	Flying an aircraft from one geographical location to another over a distance great enough to require some form of navigation
cross-feed	A system by which fuel may be fed from fuel tanks to the engines in a non-standard manner, often required in situations where a fuel-pump or aircraft engine is inoperative or when a fuel imbalance occurs
cross-wind	A wind that is blowing from any direction except directly down a runway

CSD	Constant speed drive
CSN	Cycles since new
CTAISB	Canadian Transportation Accident Investigation and Safety Board. *See* Transportation Safety Board of Canada (TSB)
CUPE	Canadian Union of Public Employees. Flight attendants of Air Ontario belong to this union.
CVFR	Controlled VFR
CVR	*See* cockpit voice recorder
CZ	Control zone
decision height	A specified height at which a missed approach must be initiated during a precision instrument approach, if the required visual reference to continue the approach to land has not been established
deferral	Postponing the rectification of a malfunction or unserviceability noted in an aircraft journey log, normally with reference to the aircraft's minimum equipment list
de-ice	The removal of ice, snow, or frost (from an aircraft)
de-icing pad	Designated area on an aerodrome where aircraft de-icing and anti-icing are carried out
DFC	Dryden Flight Centre
DFDR	Digital flight data recorder
DFO	Director of flight operations
DFTE	Designated flight test examiner
DH	Decision height

digital flight data recorder	A device that automatically records, in digital form, certain elements related to the performance of an aircraft such as engine performance and flight control position. It is used as a tool for accident investigation and, recently, aircraft maintenance
distance measuring equipment	On-board electronic equipment that provides continuous readout of the distance of an aircraft from a selected ground radio station
DM	Deputy minister
DME	*See* distance measuring equipment
DND	Department of National Defence
DOT	Department of Transport
downdraft	A localized area of descending air
E&I	Engineering and Inspection Manual
ECC	Emergency Coordination Centre
Elephant Beta	A vehicle developed in Sweden for the de-icing and anti-icing of an aircraft
elevation	The vertical distance of a point on the earth surface, measured from mean sea level
elevator	A hinged horizontal control surface connected to the horizontal stabilizer and connected to the control column to allow the pilot to control the pitch attitude of the aircraft
ELT	Emergency locator transmitter

emergency locator transmitter	A radio transmitter, attached to the aircraft structure, that operates from its own power source. It is designed to commence transmitting, without human action, following an accident. It transmits a distinctive signal on emergency frequencies for homing purposes.
empennage	An arrangement of stabilizing surfaces at the tail of an aircraft
ERR	Economic regulatory reform
ETA	Estimated time of arrival
ETD	Estimated time of departure
ETE	Estimated time en route
EWD	Equivalent water depth
FA	Flight attendant, described in the Air Navigation Orders as a cabin attendant, who is a member of the aircraft crew
FA	Area (weather) forecast
FAA	Federal Aviation Administration, the U.S. government agency responsible for safety regulations pertaining to aircraft
FACN	Area forecasts (Canadian)
FAR	Federal Aviation Regulation
FDR	Flight data recorder
final approach	The segment of the approach from the final approach fix to the point where the aircraft touches down on the runway or commences a missed approach. The final approach fix is normally three to four miles from the runway end.

FIR	Flight information region
FL	Flight level
flame-out	To cease burning in the combustion chamber of a turbine engine from a cause other than deliberate shutdown
flaps	Appendages to the wing of an aircraft that change its lift characteristics to permit slower landing and takeoff speeds
flare	Decreasing the rate of descent and airspeed by raising the nose of the aircraft just prior to landing
flashover	The spontaneous combustion of heated gases
flight data recorder	A device that automatically records certain elements related to the performance of an aircraft, such as engine performance and flight control position. It is used as a tool for accident investigation and, recently, aircraft maintenance.
flight following	A system, described in the Flight Operations Manual of an air carrier, for monitoring the progress of each flight from its point of origin to final destination, including intermediate stops and diversions. Also referred to as flight watch.
flight handbook	The title used by the aircraft manufacturer, Fokker Aircraft B.V., to describe the F-28 Mk1000 Aircraft Flight Manual; in this case, it is set out in three volumes
Flight Operations Manual	A manual produced by an air carrier for its own use and approved by the regulatory agency. It sets out the air carrier's flight operations organization, operating policies, and practices.

flight plan	Specified information related to the intended flight of an aircraft and filed with an air traffic control facility
flight release	Documentation produced by an air carrier that authorizes a given flight, including specific circumstances of such flight
flight service station	A facility operated by Transport Canada to provide information and assistance to flights. This is an advisory service only, and no traffic control is provided except as may be relayed from an air traffic control unit.
flight simulator	A flight-training device that simulates most modes of flight of a specific aircraft. It is used by air carriers to train and requalify flight crews to fly a specific aircraft.
flight watch	*See* flight following
flow control	An air traffic procedure designed to restrict the flow of aircraft during periods of excessive traffic congestion
FO *or* F/O	First officer
FOD	Foreign object damage (to an aircraft)
FOM	*See* Flight Operations Manual
forced landing	A landing that is made when it is impossible for an aircraft to remain airborne as a result of mechanical failure, such as loss of propulsion
FSO	Flight safety officer
FSS	*See* flight service station
FT	Terminal forecast
FTCN	Terminal forecast (Canadian)

GCA	Ground controlled approach
gearbox	A system of gears that transfers power from an engine to drive specific systems
GEN	Generator
g forces	Acceleration forces acting on an aircraft in flight expressed in multiples of the force of gravity
glide path (glide slope)	The vertical flight path followed by an aircraft on final approach; at times it is electronically generated by an instrument landing system
glycol	Chemical used in anti-freeze. Forms of glycol are used to de-ice and anti-ice aircraft.
GPU	*See* ground-power unit
GPWS	Ground proximity warning system
ground effect	The temporary increase in lift at very low altitudes due to compression of the air between the aircraft's wings and the ground
ground-power unit	A unit that is used to provide electrical power to an aircraft while it is on the ground
ground speed	The rate of motion of an aircraft over the ground, usually expressed in nautical miles per hour. It is the sum of the true airspeed plus or minus the effect of wind.
GS	Glide slope
Gx	International designation for Air Ontario
hard wing	A wing that has no high lift devices on the leading edge
head wind	That portion of the wind that acts to reduce the ground speed of an aircraft

holdover chart	A chart setting out guidance information as to the length of time de-icing and anti-icing fluids will protect an aircraft from contamination due to precipitation
holdover time	The time during which a de-icing or anti-icing fluid is considered to offer protection against the formation or accumulation of contaminants (frost, ice, etc.) on an aircraft
hot de-icing	De-icing of an aircraft while one or more of its main engines is running
hot refuelling	Refuelling of an aircraft while one or more of its main engines is running
HP	High pressure
HS	Hawker Siddeley (aircraft manufacturer)
HYD	Hydraulic
hydroplane	A condition in which moving aircraft tires are separated from the runway surface by a film of water, resulting in almost complete loss of brake effectiveness. Also referred to as aquaplane.
IAS	Indicated airspeed
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
IFALPA	International Federation of Air Line Pilots Associations
IFR	*See* instrument flight rules
IIC	*See* investigator in charge
ILS	*See* instrument landing system

IMC	*See* instrument meteorological conditions
incident	An aviation occurrence, other than an accident, that affects or could affect the safe operation of an aircraft
instrument flight rules	Rules for the conduct of a flight in weather conditions below those required for visual flight
instrument landing system	A ground-based electronic system designed to provide guidance in both the horizontal and vertical planes for an aircraft to follow to a runway
instrument meteorological conditions	Weather conditions expressed in terms of visibility and distance from cloud and ceiling less than the minimum required to maintain visual flight
investigator in charge	An investigator appointed by the TSB to investigate or to lead the investigation into the circumstances surrounding an aviation occurrence
ISA	International standard atmosphere
JAA	Joint Aviation Authorities
JAR	Joint Aviation Requirement
JBI	James Brake Index. It is used in indicating the coefficient of friction of a runway surface.
Jet A fuel	Jet fuel with a relatively low volatility
Jet B fuel	Jet fuel with a relatively high volatility
journey log	A log required to be carried in an aircraft. Specified information on each flight, including crew names, flying times, defects, and rectification, must be entered in this log.

Kallax De-icing System	A computer-controlled gantry-type structure, developed in Sweden and similar to a giant automobile car wash, that has the capability to de-ice and anti-ice aircraft quickly. It is normally located near the departure end of a runway.
landing gear	The components of an aircraft that support and provide mobility for an aircraft on the ground. It consists of wheels and all supporting structures.
landing roll	The segment of a landing from touchdown until the aircraft either stops or taxis off the runway
LDA	Landing distance available
leading edge	The forward edge of an airfoil
leg	A single flight from one airport to another that is part of a series of flights by the same aircraft/crew combination
LF	Low frequency
lift-dumpers	Mechanical devices installed on the wings of some aircraft, including the F-28, that, when deployed, reduce lift and increase drag on the ground in order to reduce the stopping distance
liftoff	The time during the takeoff when the wheels of an aircraft leave the runway
line indoctrination	That portion of pilot training which is carried out during normal flying operations
line pilot	An airline pilot who has no supervisory or management status
load factor	The ratio of the acceleration load on an aircraft to the weight of the aircraft

LOC	Localizer (for non-precision approach procedures predicated on a localizer facility)
localizer	An electronic component of an instrument landing system that provides the pilot with guidance to the runway centre line
logbook	*See* journey log
LP	Low pressure
M *or* **Mag**	Magnetic
MAC	*See* mean aerodynamic chord
Mach	Mach number: speed relative to the speed of sound, with the speed of sound being designated as 1
master caution (or warning) light(s)	A light or lights, normally on the instrument panel of an aircraft, designed to draw the pilot's attention to a malfunction in one of a number of systems connected to the warning system
master minimum equipment list	A document, produced by the manufacturer and approved by the certification authority, that establishes the essential aircraft equipment allowed to be inoperative, under specified conditions, for a specific type of aircraft
MCM	Maintenance control manual
MEA	*See* minimum en route altitude
Mean aerodynamic chord	Chord of imaginary wing of constant section having same force vectors under all conditions as those of actual wing
MEC	Master Executive Council (CALPA)

MEDEVAC	Medical evacuation, a term used to request air traffic services priority handling based on a medical emergency in the air transport of patients, organ donors, or organs or other urgently needed life-saving medical material. The term is to be used on flight plans and in radio-telephony communications if a pilot determines that a priority is required.
MEL	*See* minimum equipment list
MEL	Multi-engine land (endorsement of pilot's licence, referring to land-based, multi-engined aircraft)
minima, minimums	A short form for minimum descent altitude or decision height
minimum en route altitude	The published minimum altitude above sea level between specified fixes on airways or air routes which assures acceptable navigational signal coverage and meets the IFR obstruction clearance requirements
minimum equipment list	An approved document that authorizes an air carrier to operate a specific type of aircraft with essential equipment inoperative under the conditions specified
MM	(1) Middle Marker; (2) maintenance manual
MMEL	*See* master minimum equipment list
MNR	Ministry of Natural Resources
MRA	Manual of regulatory audits
msg	Message
msl	Mean sea level
MTC	Maintenance

NACIS	National Air Carrier Information System
NAMEO	Notice to Aircraft Maintenance Engineers
NASA	National Aeronautics and Space Administration (U.S.)
National Audit Program	The program of activities that measures the level of an organization's regulatory compliance with current legislation
nautical mile	A term used in navigation; it is equal to 6076 feet or 1.15 statute miles
NCATS	National Civil Air Transportation System
NDB	*See* non-directional beacon
non-compliance	The state of not meeting regulatory requirements
non-conformance	A deficiency in characteristics, documentation, or procedure that renders the quality of a product or service unacceptable or indeterminate
non-directional beacon	A low frequency radio beacon that transmits non-directional radio signals which a pilot of an aircraft with compatible receivers can use to determine his or her relative bearing
NOTAM	Notice to airmen
notice to airmen	A notice disseminated throughout the air traffic control system containing information concerning the establishment, condition, or change in any component of the National Airspace System
NTA	National Transportation Agency

NTSB	National Transport Safety Board, the United States government agency responsible for investigating and reporting on aircraft accidents
OAT	Outside air temperature
OC	*See* operating certificate
occurrence (aviation)	Any accident or incident associated with the operation of an aircraft; and/or any situation or condition that the Transportation Safety Board of Canada has reasonable grounds to believe could, if left unattended, induce an accident or incident
OFP	*See* operational flight plan
O/H	Overhaul
ojt	On-the-job training
ONF	C-FONF
ONG	C-FONG
operating certificate	A certificate issued by Transport Canada, certifying that the holder is adequately equipped and able to conduct a safe operation as an air carrier
operational flight plan	The operator's plan for the safe conduct of a flight, based on consideration of aircraft performance, other operating limitations, and relevant expected conditions on the route and at the aerodromes concerned
OPI	Office (or officer) of primary interest
OPP	Ontario Provincial Police
Ops	Operations

OSC	Onsite coordinator
out-of-trim	A situation in which the trimming devices on aircraft flight controls are not synchronized with the aircraft attitude
outside air temperature	Temperature of the air surrounding an aircraft at a distance far enough from the aircraft so as not to be affected by temperature rise due to aircraft speed
overshoot	To go beyond a designated mark or area. The term is often used to mean "missed approach."
participant	An individual representing an interested party, selected to take part in an accident investigation as a member of the investigating team
participant status	Status given to individuals or parties allowing full participation in an accident investigation
PATWAS	Pilot Automatic Telephone Weather Answering Service
PAX	Passenger
PCB	Program Control Board (subsequently, Resource Management Board)
pilot-in-command	A pilot who meets the requirements of the Air Navigation Orders and is designated as being in command of a flight
pilot-not-flying duties	Actions set out in the Aircraft Operating Manual or established through standard practice that are to be carried out by the pilot not flying the aircraft

pilot proficiency check	An annual check conducted on air carrier and other specified pilots to evaluate continuing competency on a specific aircraft type. This check is conducted to standards set out in Air Navigation Orders and may be conducted by an approved company check pilot or a Transport Canada inspector.
pilot's handbook	*See* Aircraft Operating Manual
PIP	Preliminary investigation procedures
PIREP	Pilot report of weather conditions in flight
pitch	The rotation of an aircraft around its horizontal axis. Pitch is controlled by elevators and often refers to the attitude of the aircraft in relation to the horizontal plane.
PNF	Pilot-not-flying
PPC	*See* pilot proficiency check
Program Control Board	An agency set up within Transport Canada to examine resource requests from within the department and to allocate resources to the highest-priority tasks
purser	A title often used to refer to the flight attendant who has been designated as being in charge of the cabin crew; sometimes referred to as the "in-charge"
pushback	The moving back of an aircraft from a gate by a ground vehicle
P/Y *or* **PY**	Person years
QRH	Quick reference handbook; same as checklist. It may have more or less information than a checklist, depending on the operating philosophy of the carrier.

Quality Assurance Review	A review of regional compliance with national policies, standards, and procedures in either operations or airworthiness
ramp	A defined area on an airport used by aircraft for loading and unloading passengers or cargo, for refuelling, for parking, or for maintenance
RASO	Transport Canada regional aviation safety officer
RCAF	Royal Canadian Air Force
RCC	Rescue Coordination Centre
RCMP	Royal Canadian Mounted Police
RCR	Runway condition report
RDAR	Transport Canada regional director, aviation regulation
Red 1, 2, and 3	Radio call signs of the three CFR vehicles at Dryden Airport
RLD	Rijksluchtvaartdienst (Netherlands equivalent to Transport Canada)
RMAS	Transport Canada regional manager, aviation safety programs
roll	The rotation of an aircraft around its longitudinal axis. Roll is controlled through use of ailerons or control-spoilers on the wings.
rotables	Aircraft parts that can be repaired or overhauled for re-use
rotation	During takeoff, the act of rotating the aircraft by a rearward movement of the control column in order to position the aircraft in the takeoff attitude

route bulletins	Information placed in bulletin books by Air Ontario flight operations management in order to keep pilots apprised of changes in policy or standard operating procedures
route manual	A manual provided by Air Ontario to its pilots that contains information on specific routes and aerodromes
rpm	Revolutions per minute
RSC	Runway surface condition
runup	Operation of an aircraft's engine prior to takeoff to confirm engine condition
runway designations	Runways are designated according to their orientation to the nearest 5° magnetic (or true). Where two parallel runways exist, they are further designated left and right.
runway threshold	The beginning of that portion of the runway which is usable for takeoff or landing
runway visual range	An instrumentally derived value, expressed in hundreds of feet, which represents the horizontal distance the pilot would be able to see down the runway at the point where the instrument is located
RVR	Runway visual range
SA	Station actual weather (weather report)
SAE	Society of Automotive Engineers
SAR	Search and rescue
self-dispatch	The planning and execution of a flight or series of flights, being the sole responsibility of the captain
SID	Standard instrument departure

side-slip The controlled flight of an aircraft in a direction not in line with its longitudinal axis. It requires cross controlling by the pilot; that is, application of aileron in one direction and rudder in the opposite direction.

SIGMET Significant meteorological report

simulator *See* flight simulator

slats Devices that can be extended from the leading edge of an airfoil in order to increase lift at low speeds

slipstream The stream of air discharged aft of a revolving propeller

slot time A time assigned to a pilot by air traffic control at which a departure clearance may be expected

SMOH Since major overhaul

snag A system or component malfunction or unserviceability entered in a journey log

SOC System operations control

SOPs Standard operating procedures

speed brake *See* air brake

Spey engines The common name for the Rolls-Royce engines installed on the F-28

spoilers *See* lift-dumpers

stall The sudden loss of lift of an airfoil when it exceeds its critical angle of attack (maximum lift coefficient)

stall fence A fence on an airfoil, its primary purpose being to improve behaviour at stall

standard operating procedures (SOPs)	The procedures reflected in a flight operations manual, an aircraft operating manual, or even a route manual that could be, and sometimes are, referred to as standard operating procedures. *See* Aircraft Operating Manual.
stick-shaker	A device that will induce rapid control column movement to warn the pilot that the airfoil is approaching the stall
STOC	Station operations control
STOL	Short takeoff and landing
stopway	A prepared surface at the end of a runway, to be used as required when stopping an aircraft. It is not built to the specifications of the runway and is not used during takeoff.
SVFR	Special VFR
swept wing	An aircraft wing that slopes in plan form so that the wing tip is further aft than the wing root. The angle formed by the fuselage and the wing leading edge is the degree of sweep.
system operations control	A group designated by an air carrier to carry out operations planning and economical utilization of aircraft and personnel. Note that operations control is distinct from operational control.
TACAN	Tactical air navigation aid (UHF omni range)
tail plane	An airfoil, located aft of the main airfoils, contributing to longitudinal control and/or stability

takeoff	(1) Procedure in which aircraft becomes airborne; (2) moment or place at which aircraft leaves ground or water; (3) net flight path from brake-release to screen height. (Note: Screen height is the height above ground of the top of screen on takeoff, normally 35 feet, which is measured at the end of the takeoff distance.)
takeoff alternate	An airport, designated as the landing airport in case of an emergency, where a takeoff is conducted in weather conditions that do not allow a landing at the airport of departure
takeoff distance available	The length of the takeoff run available plus the length of clearway, if provided
takeoff run available	The length of runway declared available and suitable for the ground run of an aircraft taking off
TAS	True airspeed
taxi	To operate an aircraft under its own power on the ground, except for takeoff or landing
taxiway	A specially prepared or designated path on an aerodrome, for use by taxiing aircraft
TBO	Time between overhaul
TC	Transport Canada
TCA	Terminal control area
TCAG	Transport Canada Aviation Group
TCU	Terminal control unit
TDZ	Touchdown zone
team leader	An individual designated by the audit manager to conduct a specific part of the audit
TGT	Turbine gas temperature

threshold	*See* runway threshold
thrust	The propulsive force developed by a jet engine, usually expressed in pounds
thrust-reverser	A device used on the ground to deflect the airflow from a turbojet engine forward in order to assist in slowing the aircraft
TI	Technical inspector
TL	Technical log
TODA	Takeoff distance available
TORA	Takeoff run available
touch-and-go	Where an aircraft touches down on the runway and the pilot deliberately takes off again. It is usually carried out in order for pilots to practise approaches and landings.
touchdown	The point where the wheels first touch the runway during a landing
touchdown zone	The first 3000 feet of runway from the threshold in the direction of landing
TP	Indicates a Transport Canada publication
transmissometer	A device used for the determination of runway visual range
trim	The positioning of flight controls and/or trim tabs so the aircraft will maintain a desired attitude in steady flight
true airspeed	Speed of the aircraft through the air corrected for air density (altitude and temperature)
trunk-feed (feeder-trunk)	Refers to the relationship between a national or international air carrier and its regional affiliate

TSB	Transportation Safety Board of Canada, the Canadian government agency responsible for investigating and reporting on transportation occurrences
TSN	Time since new
TSO	Time since overhaul
turbofan (engine)	A turbojet engine in which thrust is produced both by jet propulsion and by a fan (propeller) contained within the engine cowlings
turbojet (engine)	An engine using jet propulsion to provide forward thrust
turboprop aircraft	An aircraft driven by propellers that are powered by a turbojet engine
turn-and-bank indicator	A gyroscopic instrument for indicating the rate of turning and the degree of coordination or yaw
TWB	Transcribed weather broadcast
TWR	Control tower
Type I fluid	A de-icing fluid composed of a mixture of glycol, water, and anti-corrosive and wetting agents that is heated and sprayed on aircraft. The fluid removes contaminants and offers limited protection against icing.
Type II fluid	A glycol-based anti-icing fluid containing corrosion inhibitors, wetting agents, and polymeric thickeners. This pseudo-plastic fluid, applied at ambient temperatures, provides protection against the accumulation of ice and snow on aircraft; it is not used as a de-icing fluid.

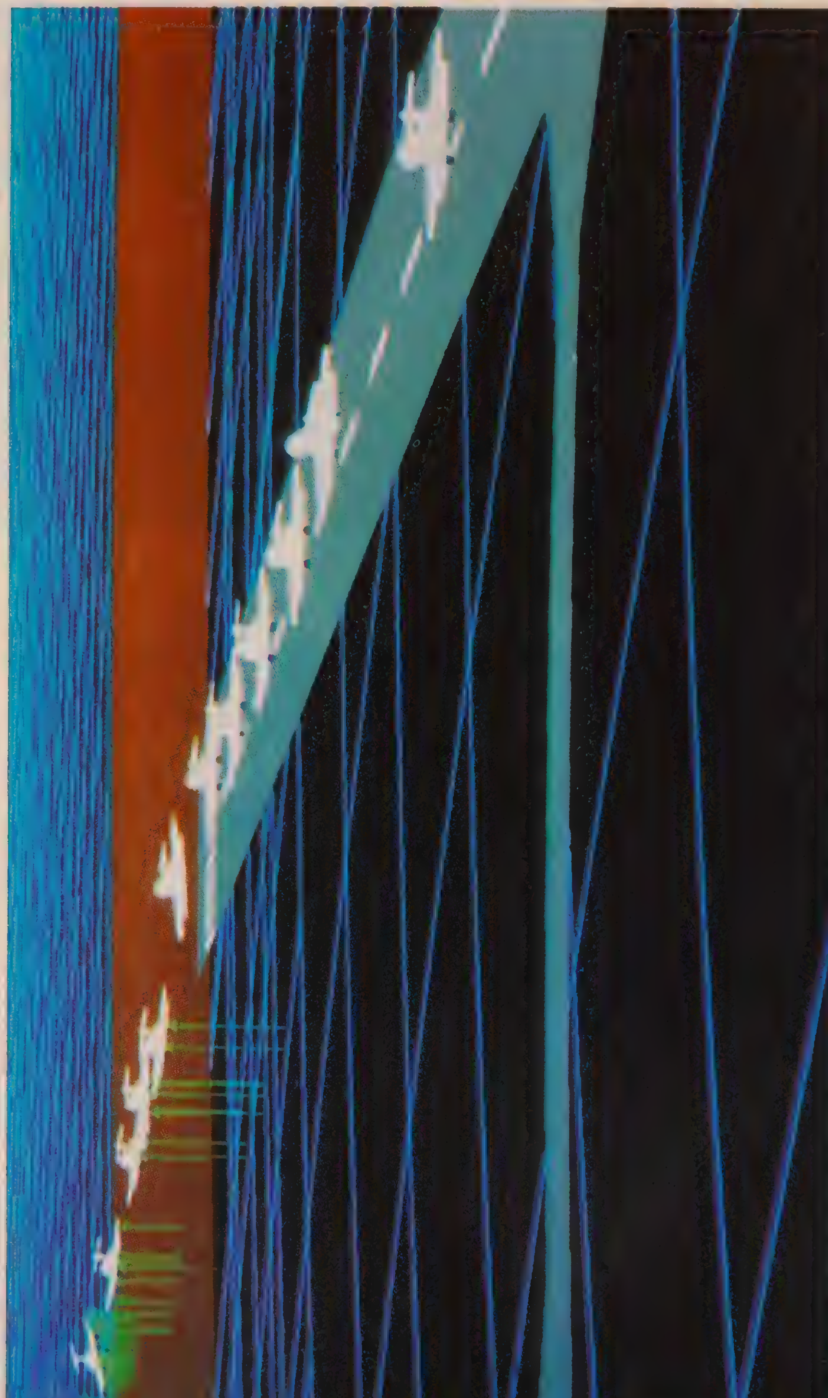
UNICOM	A radio facility operated by agencies, other than Transport Canada, at an uncontrolled aerodrome to provide information to aircraft operating in the area. No air traffic control is provided.
unserviceable	The state of a system or component where that system or component is not capable of carrying out the function for which it is designed
updraft	A localized area of rising air
u/s	Unserviceable
UT of O	Unorganized Territories of Ontario (firefighters)
UTC	Coordinated Universal Time
V_1	Takeoff decision speed: the aircraft speed during takeoff at which the pilot, having recognized the failure of the critical engine, decides whether to continue with the flight or stop the aircraft
V_2	Takeoff safety speed: the minimum speed at which an aircraft is allowed to climb after reaching a height of 35 feet on takeoff
V_R	Takeoff rotation speed: the speed during takeoff at which the pilot initiates rotation of the aircraft to cause the aircraft to become airborne
VASIS	Visual approach slope indicating system. VASIS consists of a series of lights used to provide vertical visual guidance to pilots on final approach to a runway.
vector	A magnetic heading maintained by an aircraft at the request of air traffic control
VFR	*See* visual flight rules

visual approach	A normal visual approach or an approach where an aircraft on an IFR flight plan, operating in VFR weather conditions and having ATC authorization, may proceed to an airport using visual references only
visual flight rules	Rules that provide for flight having continuous visual reference to the ground or water and requiring specified minimum weather conditions
visual meteorological conditions	Weather conditions expressed in terms of visibility and distance from cloud and ceiling equal to or greater than specified minima for VFR flight
VMC	Visual meteorological conditions
VNC	VFR navigation chart
VOLMET	In-flight meteorological information
VOR	Very high frequency (VHF) omni-directional range
walkaround	An external visual examination of an aircraft carried out prior to a flight
whiteout	Loss of orientation with respect to the horizon, caused by uniform light conditions from sky and snow
wind shear	A change in wind velocity along an axis at right angles to the general wind direction; usually specified as vertical or horizontal
wind sock	A cloth sleeve mounted aloft at an airport, for use in estimating wind direction and speed
WX	Weather
YAM	Sault Ste Marie airport

yaw	The rotation of an aircraft around its vertical axis. Yaw can be induced or corrected by use of the rudder on the vertical stabilizer.
YHD	Dryden airport
YQK	Kenora airport
YQT	Thunder Bay airport
YWG	Winnipeg airport
YXU	London airport
YYZ	Toronto/Lester B. Pearson International airport
Z	Zulu time (UTC)

Ontario C-FONF the ground in ınder Bay on Feb-ry 21, 1989; this otograph was taken a passenger board-flight 1363 for yden that day.

ese views of Air tario's other F-28, ONG, show the ts available on this craft.

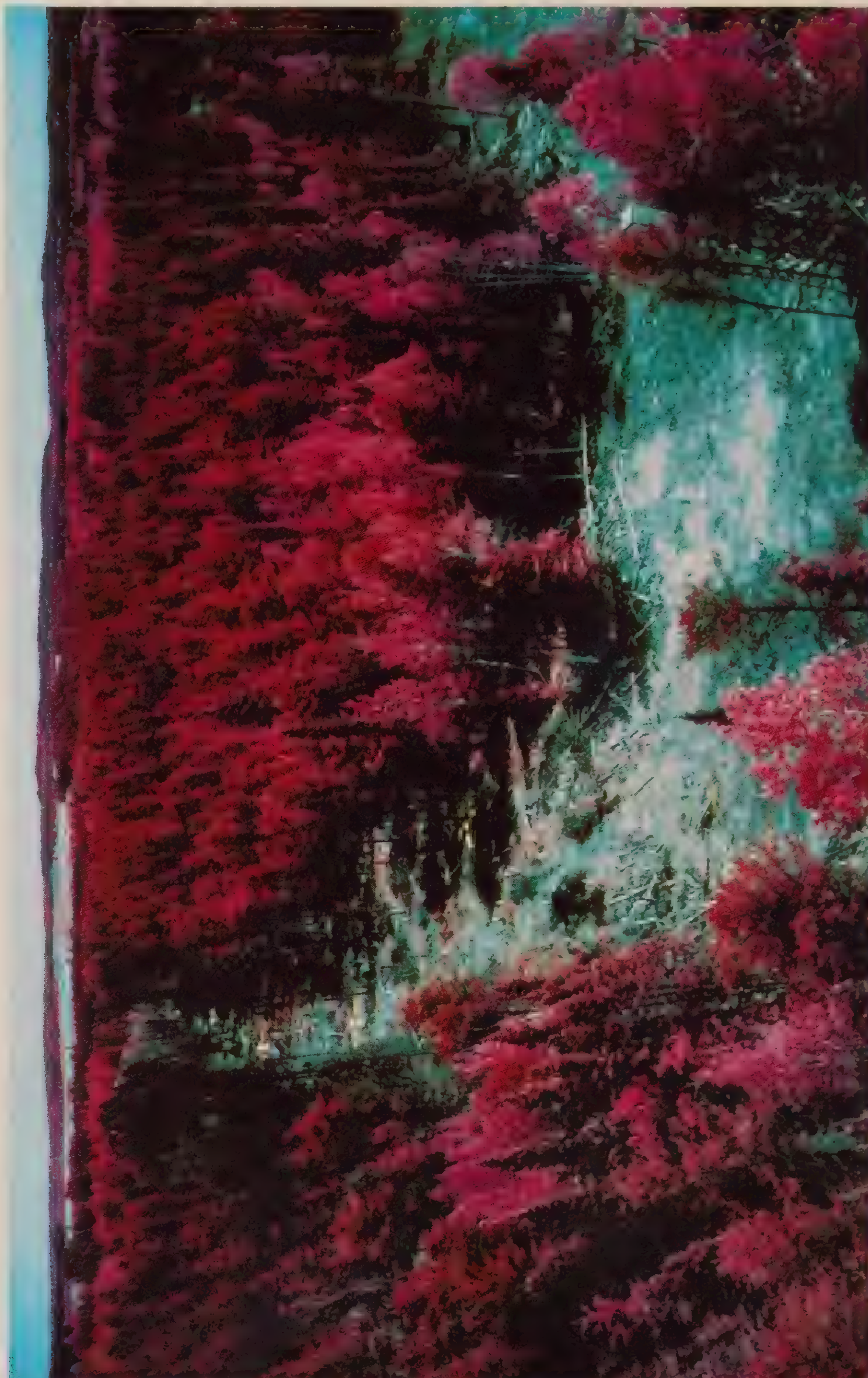


Computer-generated reconstructions of the takeoff were prepared for the Commission of Inquiry by the Canadian Aviation Safety Board (CASB) as part of the investigation of the crash. The first shows the aircraft from the perspective of the terminal: passing taxiway Alpha, attempting liftoff, settling back onto the runway, lifting off again towards the

This reconstruction gives an aerial view of Dryden Municipal Airport and the takeoff attempt of flight 1363 on runway 29 on March 10, 1989.

An aerial view, showing the flight path of C-FONF on March 10, 1989.

An aerial view of the wreckage of C-FONF, showing the aircraft in three pieces. The Air Ontario designator is clearly visible on the tail section.



This infrared photograph shows the extent of the fire damage to trees along the flight path.

These photographs, taken by one of the fire-fighters in mid-afternoon March 10, 1989, convey the intensity of the fire which, by this time, is nearly extinguished.

By 2:00 p.m. the port-a-pond was set up on Middle Marker Road, filled from the tanker truck in the foreground, and foam was available to fight the fire.

An emergency road was bulldozed in to give access to the crash site.

Investigators from the Canadian Aviation Safety Board (CASB) arrived at the site about noon on March 11, 1989.

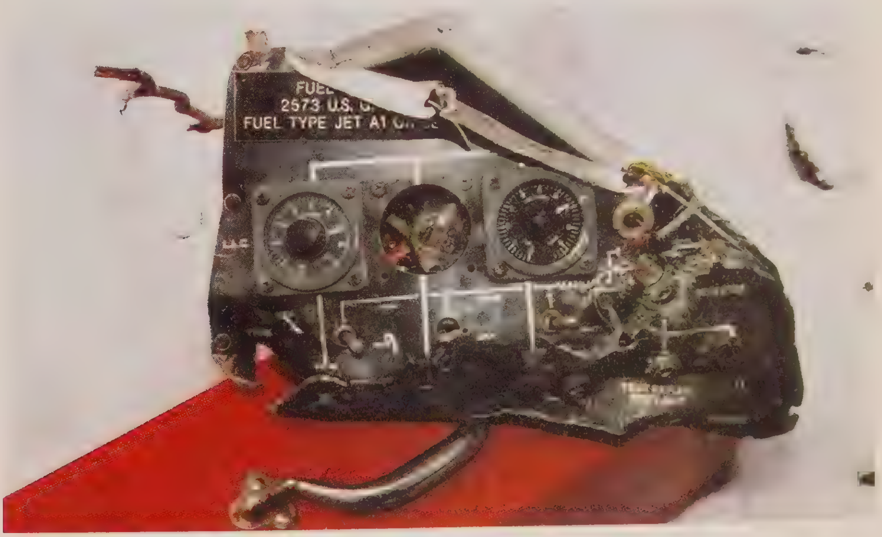
The path of flight 1363 is clear in this photograph taken by CASB investigators, looking west from runway 29 of Dryden airport.

The wreckage trail looking east from the site of the crash

The wreckage trail looking west towards the wreckage from part way along the trail

The wreckage trail shot through the fuselage of the aircraft

The cockpit voice recorder and flight data recorder were recovered, buried in debris, approximately 24 hours after the crash. On disassembly, it was discovered that the recording medium of both recorders had been destroyed by severe heat damage.



The refuelling panel, located in the wing, shows a fuel load of approximately 14,000 lbs.

The wreckage was carefully photographed in situ at the crash site by the investigators: top, right engine; bottom, rear section of the right side of the fuselage.

The aircraft was dismantled and transported to Ottawa for examination. These photographs show the left engine being removed and loaded onto a truck.

The tail section and part of the nose cone and fuselage centre section were moved from the crash site.

The aircraft sections were loaded onto gondola railway cars for transportation to Ottawa.

The aircraft wreckage was delivered to CASB's Engineering Branch in Ottawa for examination and analysis.

PART ONE

INTRODUCTION


RED LAKE
PICKLE LAKE
MANITOBA
ONTARIO
N
W
E
S
WINNIPEG
SIOUX LOOKOUT
KENORA
DRYDEN
VERMILION BAY
CANADA
FT. FRANCES
THUNDER BAY
RAINY RIVER
INT'L FALLS
LAKE SUPERIOR
SAULT
STE
MARIE
N. DAKOTA
MINNESOTA
DULUTH
MICHIGAN
U. S. A.
LAKE MICHIGAN
MINNEAPOLIS
WISCONSIN
MICHIGAN
MILWAUKEE
IOWA

1 INTRODUCTION

The Accident

On Friday, March 10, 1989, at approximately 12:11 p.m. Central Standard Time (CST),[1] Air Ontario flight 1363 crashed approximately 962 metres off the end of runway 29 after takeoff from the Dryden Municipal Airport. Air Ontario flight 1363 was a scheduled flight from Thunder Bay to Winnipeg via Dryden. The aircraft was a Fokker F-28 Mk1000 bearing Canadian registration C-FONF.

There were 65 passengers and a crew of four on board. The aircraft failed to gain altitude after its attempted takeoff from runway 29 and continued on a flat flight path, barely clearing a bluff approximately 700 metres from the end of the runway and crashing into a densely wooded area. In all, 21 passengers and three crew members, including the captain, the first officer, and one of the two flight attendants, died as a result of the crash and the accompanying fire.

There was extensive physical and fire damage to the aircraft, which resulted in the destruction of the flight data recorder (FDR) and the cockpit voice recorder (CVR) tapes. The loss of the FDR and the CVR data necessitated a detailed reconstruction of the crash sequence.

The Initial Investigation

An investigation into the crash of flight 1363 was immediately undertaken by the Canadian Aviation Safety Board (CASB) pursuant to the *Canadian Aviation Safety Board Act*, R.S.C. 1985, c.C-12 (the *CASB Act*). The investigator in charge (IIC), Mr Joseph Jackson of Ottawa, attended at Dryden on March 11, 1989, with a team of 21 CASB investigators. The CASB team carried on with its investigation as it would in any major accident investigation, interviewing witnesses and analysing the aircraft wreckage.

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[1] Local time will be used throughout this Report unless otherwise indicated. It should be noted that Dryden and Winnipeg are located within the Central time zone while Thunder Bay is located within the Eastern time zone. Thunder Bay time is one hour ahead of time in Dryden and Winnipeg.

On March 29, 1989, the CASB investigation was suspended and this Commission of Inquiry was established to inquire into the contributing factors and causes of the crash. I, as Commissioner, was authorized to make such recommendations as I may deem appropriate in the interests of aviation safety.

Following the formal establishment of the Commission, I took immediate steps to reactivate the accident investigation. I contacted the then chairman of CASB, Mr Ken Thorneycroft, and requested that certain CASB aviation accident investigators, including the IIC, be seconded to this Commission to assist in the conduct of the inquiry. This was done and, with the complete cooperation of CASB, the investigation of the crash of flight 1363 was transferred to this Commission.

Interpretation of Terms of Reference

In my opening statement on June 16, 1989, I commented upon my interpretation of the terms of reference of this Inquiry:

> I interpret the terms of reference to provide a broad mandate to inquire not only into the Air Ontario crash but also into any derivative matters which affect aviation safety, with respect to which I am directed to make such recommendations as I may deem appropriate. The Commission may, from time to time, enlarge, consolidate, delete, and/or modify any of the said areas of inquiry as the evidence unfolds.
>
> (Transcript, vol. 2, p. 51)

My interpretation has remained consistent throughout the life of the Commission.

I have interpreted the terms of reference to provide a broad mandate to inquire not only into the Air Ontario crash but also into any derivative matters that affect aviation safety. Essentially, the Commission was to conduct a thorough investigation in order to allow an assessment of the contributing factors and causes of the crash of flight 1363. This included the necessity to identify persons or organizations that may have contributed to the accident.

Aviation Accident Investigation: The System Approach

Modern air transportation is a complex enterprise. Similarly complex are the causes of aircraft accidents. Previous aircraft accident investigations have demonstrated that an accident or serious incident is not normally

the result of a single cause, but rather the cumulative result of oversights, shortcuts, and miscues which, considered in isolation, might have had minimal causal significance.

To assess all of the contributing factors and causes of this accident and to make recommendations in the interest of future accident prevention, this Commission adopted an analytical and a "system" approach to facilitate a methodical and thorough investigation of the accident. The system approach identifies the main components of the air transportation system and calls for an assessment of the performance of each of these components.

The components of the air transportation system are generally categorized as follows:

- the aircraft crew (including the pilots and the cabin crew)
- the aircraft
- the immediate operational infrastructure (including airport facilities, navigation aids, weather, and other communications facilities)
- the air carrier
- the regulator.

The aircraft crew, being immediately responsible for the safe carriage of the passengers, is the focal point of the entire air transportation system. The aircraft crew members must contend with the total operating environment of a given flight and any constraints placed upon them by their aircraft, their air carrier, the immediate operational infrastructure, and the regulator. The serviceability of the aircraft, the operational control of a particular flight, and the overall operational and flight safety ethic within which the crew functions are the products of air carrier management. The air carrier, in turn, operates in a highly regulated environment where the regulator is expected to establish and monitor standards for the aviation industry.

The evidence arising out of the Dryden crash has convinced me of one point above all: because of the potentially catastrophic consequences of a failure in the air transportation system, the aviation industry must operate within a regime of clearly defined and well-enforced standards. In Canada the standards of the air transportation system should be of the highest order that current technology permits.

A properly functioning air transportation system with appropriate standards operates as an ongoing check against the circumstances that can give rise to an accident. It became clear from the evidence that, when one or more of the components in the system breaks down, the probability of an accident or serious incident is increased. The accident at Dryden on March 10, 1989, was not the result of one cause but of a combination of several related factors. Had the system operated

effectively, each of the factors might have been identified and corrected before it took on significance. It will be shown that this accident was the result of a failure in the air transportation system.

The ultimate goal of this Inquiry, like that of all accident investigations, is to prevent future accidents. To this end I am of the view that a review of certain aspects of the air transportation system is most important. Accordingly, my approach has been to examine the relevant facts surrounding the accident and to assess whether the existing system reacted, or was capable of reacting, as it should have. After more than two years of intensive investigation and public hearings, I believe that this accident did not just happen by chance – it was allowed to happen.

The Components of the Commercial Air Transportation System

Having accepted an analytical framework for the investigation of this accident, I am of the view that my mandate required me to examine the components of the air transportation system and to assess reasons for the various failures in the system that, together, caused the crash of the aircraft on March 10, 1989. Accidents are, of course, often the result of several complex factors.

The Aircraft Crew

The aircraft crew is a significant component in the air transportation system. Pilots and flight attendants are trained professionals, and the travelling public has a right to expect that crew members will carry out their duties in a professional, competent manner.

As the performance of the regulator and the air carrier will be scrutinized, so too will there be an assessment of the conduct of the four crew members on flight 1363.

Captain George Morwood

Captain George Morwood, age 52, was an experienced pilot with approximately 24,100 flying hours. He received his commercial pilot's licence in 1955 and worked in a variety of flying jobs until 1973, when he joined Great Lakes Airlines, a predecessor to Air Ontario. He was employed by Air Ontario until his death in the crash on March 10, 1989.

During his career, Captain Morwood gained qualification on a number of aircraft types, including the Convair 440, a 55-passenger piston-engine propeller aircraft; the Convair 580, a 55-passenger turboprop aircraft; and the Grumman Gulfstream II, an executive jet. He received his qualification on the F-28 in January 1989 and, by the date of the accident, had

acquired 81.63 hours on that aircraft type. The F-28 was the largest jet aircraft he had flown, and the only jet aircraft he had flown in scheduled commercial service. Captain Morwood was described by his peers as a conscientious and competent pilot, who, to use the vernacular, "flew by the book."

Because Captain Morwood had fewer than 100 hours as pilot-in-command on the F-28 aircraft by March 10, 1989, he was under certain operational restrictions with regard to takeoff and landing weather limits. The determination of these limits is discussed in chapter 38 of this Report, Crew Information.

First Officer Keith Mills

First Officer Keith Mills, age 35, became a commercial pilot in 1975. In 1979 he joined Austin Airways Limited, another predecessor of Air Ontario Inc.

While at Austin Airways, he gained qualification on the Cessna 402, a seven-passenger piston aircraft; the de Havilland Twin Otter, a 19-passenger turboprop aircraft; the Hawker Siddeley HS-748, a 43-passenger turboprop aircraft; and the Cessna Citation, an executive jet.

First Officer Mills received his qualification on the F-28 in February 1989 and, by the date of the accident, he had acquired 65.7 flying hours on that aircraft type. He was described by his colleagues as an assertive pilot, and he had a satisfactory record with Transport Canada.

In spite of their considerable flying experience, neither Captain Morwood nor First Officer Mills had much experience on the F-28. "Low-time on type" crew pairings have been the subject of investigation and have been identified as causal factors in other aviation accidents, as will be discussed in chapter 40 of this Report, Human Performance.

Flight Attendant Katherine Say

Katherine Say, age 31, was a flight attendant with 10 years' experience and had been employed by Austin Airways and Air Ontario Inc. throughout that time. She was promoted to in-flight coordinator in February 1989. Mrs Say was considered by her colleagues to be an excellent crew member with a professional approach to her duties.

Flight Attendant Sonia Hartwick

Sonia Hartwick, the sole surviving crew member, was 26 years old on the day of the accident. She had two-and-a-half years' experience as a flight attendant, all with Austin Airways and Air Ontario. Along with Mrs Say, she had received the F-28 flight attendant training course

offered at Air Ontario, and was considered competent and professional in her work.

The Aircraft

The F-28 Mk1000 aircraft, C-FONF, was manufactured by Fokker Aircraft B.V. of the Netherlands. Its design and construction met the American certification criteria stated in Civil Air Regulation 4(b). It began flying in 1967 and was authorized for Canadian operation in 1972, when it received aircraft type approval from the Department of Transport.

The F-28 Mk1000 aircraft was last manufactured in 1976. It was designed for the short- to medium-range jet transport market and a brisk resale market exists for the model. A typical configuration of this aircraft will accommodate 65 passengers, requiring a crew of two pilots and two flight attendants.

The manufacture of aircraft C-FONF was completed on November 2, 1972, and from 1973 to 1987 it was part of the fleet of Turk Hava Yollari (THY), the Turkish national airline. It was powered by two Rolls-Royce Spey Model 555-15 engines manufactured in Great Britain. In 1987, after having been "mothballed" by THY in Turkey for two years, the aircraft was sold to Transport Aérien Transrégional of France and subsequently leased to Air Ontario in November 1987. It received a Canadian certificate of airworthiness on May 30, 1988, and its Canadian registration as C-FONF on June 13, 1988. Air Ontario was given a temporary amendment to its operating certificate on May 31, 1988, authorizing F-28 operations. Its operating certificate was formally amended to include the F-28 on June 10, 1988.

At the time of the accident Air Ontario was operating two F-28 Mk1000 aircraft: C-FONF and C-FONG.

The Carrier: Air Ontario Inc.

Air Ontario Inc. (Air Ontario) is the product of a functional merger[2] between Austin Airways Limited (Austin Airways) and Air Ontario Limited that occurred in June 1987. Before the merger, Austin Airways was the largest regional air carrier in Northern Ontario, with its main base of operations in Timmins. Between 1974 and the 1987 merger, this

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[2] Though the terms "merger" or "functional merger" were used in testimony to describe the June 1987 union of Austin Airways Limited and Air Ontario Limited, there was never a formal amalgamation of the two companies. What actually occurred was an acquisition of the assets of Air Ontario Limited by Austin Airways. Austin Airways then changed its name to Air Ontario Inc., while Air Ontario Limited, having been stripped of its assets, was wound up. The terms "merger" and "functional merger" will be used in this Report as they were used by the witnesses who appeared before me.

largely charter and cargo operation prospered under the ownership and management of the Deluce family of Timmins, Ontario. At the time of the merger, Austin Airways had a fleet of 30 aircraft of seven different types. These aircraft ranged in size from the seven-passenger Cessna 402 to the 43-passenger Hawker Siddeley HS-748.

Air Ontario Limited, based in London, Ontario, provided scheduled service primarily in southern Ontario. At the time of the merger, Air Ontario Limited operated the 55-passenger Convair 580 aircraft exclusively.

In January 1987 Air Canada purchased a 75 per cent voting interest in both Air Ontario Limited and Austin Airways, with the Deluce family retaining a 25 per cent voting interest in the companies. In June 1987, after operating separately for five months, Air Ontario Limited and Austin Airways were functionally merged under the name Air Ontario Inc. After the merger, Air Canada and the Deluce family retained the same 75:25 ownership interests in the new Air Ontario Inc.

Air Ontario Inc. functioned as a regional "feeder" airline to Air Canada's national transportation network. Because of a common marketing, ticketing, and scheduling arrangement, Air Ontario passengers were able to benefit from the coordinated connection of their Air Ontario regional flight to a national or international Air Canada flight.

Air Ontario was one of several regional airlines across Canada that fed into Air Canada "hubs" at major airports. Air Ontario was the primary regional feeder for Air Canada at Lester B. Pearson International Airport. To a lesser extent, Air Ontario provided a regional feed into Winnipeg International Airport.

By the date of the accident, Air Ontario Inc. was a different airline from the one that existed at the time of the merger in June 1987. It had divested itself of most of its old Austin Airways northern routes and had become primarily a scheduled carrier based in London, Ontario, operating Convair 580, Dash-8, and F-28 aircraft.

The Regulator: Transport Canada

Transport Canada is the body charged with the responsibility for the promulgation and enforcement of aviation regulations and standards in Canada. Furthermore, Canada is a signatory to a number of international conventions that define additional standards under which passengers are carried by air.

The reason for this degree of regulatory involvement is straightforward. A safe and reliable air transportation industry is important to the economic well-being of Canada. Equally obvious is the proposition that the regulator owes a duty to the travelling public to keep the industry

as safe as practicable. The regulatory duty arises from the fact, which is often overlooked, that the public has given the regulator its trust.

The *Aeronautics Act*, R.S. 1985, c.A-2, and the Air Regulations, C.R.C. 1978, c.2 (Air Regulations), together with the Air Navigation Orders (ANOs), are the legislative instruments governing Canadian aviation. Operating standards for air carriers, like Air Ontario, using large aircraft[3] are set out in Air Navigation Order Series VII, No. 2, C.R.C. c.21 (ANO Series VII, No. 2).

Pursuant to section 4.2 of the *Aeronautics Act*, the minister of transport "is responsible for the development and regulation of aeronautics and the supervision of all matters connected with aeronautics" in Canada. Transport Canada is the federal department that gives effect to the minister's statutory mandate.

There are two groups within Transport Canada responsible for aviation: the Airports Authority Group and the Aviation Group. The Airports Authority Group is responsible for the development, maintenance, and operation of essential airport services throughout Canada. The Aviation Group is divided into two significant branches:

- the Air Navigation Systems Branch, which is responsible for, among other things, air traffic control and navigation and communication systems; and
- the Aviation Regulation Branch, which is responsible for the development and promulgation of regulations and standards; the certification and monitoring of aviation personnel, airlines, aircraft, and aeronautical products; and the enforcement of the *Aeronautics Act*, Air Regulations, and ANOs.

The Aviation Group is divided administratively into a national headquarters and six regions: Atlantic, Quebec, Ontario, Central, Western, and Pacific regions. Each is responsible for the regulation of aviation in Canada. The ongoing regulation of Air Ontario Inc., as a commercial air carrier based in London, Ontario, was the responsibility of the Ontario regional office.

Carriers' Obligation and Regulator's Duty

As will become clear throughout the Report, the regulator – Transport Canada – has imposed significant responsibilities in the area of flight safety on individual Canadian air carriers.

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[3] "Large aircraft" means an aircraft of more than 12,500 pounds maximum certificated takeoff weight (ANO Series VII, No. 2, s.2).

The provision of an acceptable level of flight safety is an obligation owed by both the air carrier and the regulator to the Canadian travelling public. The regulator, as an arm of government, has a duty to the public to fulfil its role in the promulgation and enforcement of legislative standards within the air transportation system. A licensed air carrier has an obligation to comply with the standards set out in the applicable legislation. As discussed in later chapters of this Report, the legislation governing Canadian commercial air carriage is not universally comprehensive or exhaustive. While in some areas the legislative requirements are detailed and well developed, in other areas the legislation is broadly worded and indefinite.

For example, air carriers are directed by the ANOs to conduct their operations "in a proper manner," leaving it up to an individual carrier and regulator to come to an agreement as to what is "proper" under the circumstances. If there is scope for interpretation, it must be emphasized that air carriers cannot simply rely on legislation to define the limits of their flight safety obligations. As is the case with any business enterprise, air carriers must conduct their affairs in a reasonable and prudent manner.

The fulfilment of flight safety obligations is part of the operating costs for air carriers. Again, as is the case with any commercial enterprise, success will be the result of the prudent balancing of commercial considerations with legislated and civil obligations.

The duty owed by a carrier to its passengers is not mitigated by inadequate or absent legislation, but rather it is independent of the regulator's obligations within the safety system. Throughout this Report, certain deficiencies within Transport Canada will receive comment. Air Ontario's corporate role in this accident is assessed against what I view to be its independent obligation to its passengers. Air Ontario, independent of regulatory requirements, is obliged to its passengers to provide the highest standard of flight safety reasonably available.

Within a regulated industry, legislation that is perceived as commercially threatening will be resisted by that industry. The Canadian air transportation industry is no different. The regulatory process in Canada, in fact, allows for discourse between the regulator and industry when such issues arise. This process ensures that the regulator will consider the economic viability of proposed legislation as well as its implications on flight safety.

When the regulator is faced with the choice between the commercial viability of an individual operator and the highest level of safety reasonably available to the travelling public, I am of the view that, for the reasons previously stated and later elaborated upon, the duty to the public must take priority.

It is against the propositions of the corporate obligation and the legislator's public duty that I have weighed the actions of Air Ontario and Transport Canada in determining their effectiveness as components of the air transportation system.

PART TWO

FACTS SURROUNDING THE CRASH OF FLIGHT 1363

2 AIR ONTARIO FLIGHTS 1362 AND 1363

Winnipeg

The four Air Ontario crew members, Captain George Morwood, First Officer Keith Mills, and flight attendants Katherine Say and Sonia Hartwick, arrived at the Air Canada counter of Winnipeg International Airport at 6:40 a.m. on March 10, 1989, to prepare for the day's flying.[1] Their scheduled flights consisted of a Winnipeg to Thunder Bay return trip, with intermediate stops at Dryden (flights 1362 and 1363), followed by another Winnipeg to Thunder Bay return trip without the Dryden station stop (flights 1364 and 1365). In all, there were six legs to their scheduled flying on March 10. Their first departure from Winnipeg was scheduled for 7:25 a.m., with the final landing at Winnipeg scheduled for 3:30 p.m. As was normal before the first flight of any day, the crew checked on the weather and the condition of the aircraft, and received the company flight authorization (flight release).

The Weather, Fuel and Passenger Loads, Aircraft Weight

The area weather forecasts for the day's operations showed generally unsettled and deteriorating weather, including lowering cloud ceilings and freezing precipitation as the day progressed. Terminal weather forecasts for Thunder Bay and Winnipeg were available to the crew before their departure. These forecasts indicated conditions that could potentially deteriorate to below the captain's landing limits at their scheduled arrival times. There was no terminal weather forecast for Dryden available at this time.

Because of these forecasts of unsettled weather, the crew had to accommodate deviations from normal flight planning. Air Regulations

[1] Air Ontario utilized Air Canada station facilities at Winnipeg and Thunder Bay. These Air Canada Station Operations Control (STOC) centres often provided communication links between Air Ontario pilots and their own System Operations Control (SOC) facilities in London. Air Ontario aircraft had no direct radio communications link with Air Ontario SOC. Air Ontario pilots could communicate with their SOC by a radio call to an Air Canada STOC, which would in turn relay messages via telephone to Air Ontario SOC.

require that an aircraft carry fuel sufficient to fly to an alternate airport (alternate) in case the crew is unable to land the aircraft at its planned destination. The crew of C-FONF had to plan for Sault Ste Marie as an alternate, and because it was a more distant alternate than usual, they had to carry a greater fuel load. Fuel and passenger loads are two significant variables in the calculation of total aircraft weight. The F-28, like all commercial aircraft, is limited by maximum takeoff and landing weights.

As it happened, March 10, 1989, was the Friday before the Ontario spring school break. A heavy passenger load from Thunder Bay to Winnipeg, which included many families commencing their vacations, combined with the extra fuel required to accommodate the longer alternate, necessitated a refuelling on the second Dryden station stop. Normally, fuel would not be taken on in Dryden.

The Flight Release

Each Air Ontario revenue flight must, in accordance with Air Regulations and the company's Flight Operations Manual, be specifically authorized before departure. Normally this is done through the issuance of a flight release by Air Ontario System Operations Control (SOC) in London. The flight release is then sent by telex to the point of departure, where it is picked up by the captain of the planned flight, and to all online stations.

The flight release contains significant operational information that governs the conduct of all flights. It is typically planned and prepared by the SOC in London before the intended flights. The flight release specifies the planned alternates, aircraft weights, fuel consumption, passenger loads, and other operational information necessary for the crew to conduct its flights in a safe and orderly manner. The flight release is a document used by Air Ontario to fulfil its fundamental obligation to exercise operational control over its aircraft (see chapter 23, Operational Control).

The flight release made available to Captain Morwood on the morning of March 10, 1989, at Air Canada Station Operations Control (STOC) in Winnipeg contained numerous errors. It was prepared and issued by an Air Ontario SOC dispatcher who was untrained and unfamiliar with the operational characteristics of the F-28 aircraft. The errors in the flight release should have been manifest to a pilot of Captain Morwood's experience and reputation and to First Officer Mills. Somewhat uncharacteristically, Captain Morwood did not contact Air Ontario SOC on the morning of March 10 to rectify the errors and have a new flight release issued.

The Unserviceable Auxiliary Power Unit

When Captain Morwood reviewed the operational state of his aircraft, he would have discovered that the auxiliary power unit (APU) was unserviceable. The APU normally provides compressed air and electrical power to various aircraft systems while the aircraft is on the ground. A flow of compressed air is required to start the F-28 main engines, and this flow is usually supplied by the APU. After one main engine is started with the APU, that engine can generate its own compressed air to start the other engine via a cross-bleed start. An independent source of compressed air such as an air compressor or an "air bottle"can be used to start the aircraft's main engines whether or not an APU is functioning.

The APU on C-FONF had not been functioning normally for the five days preceding the accident. On occasion, it was not producing enough air pressure, a deficiency that caused high engine temperatures during startup. On several occasions while in flight, an oily mist or smoke was observed in the passenger cabin and was detected by the cabin smoke alarm. Although never confirmed, this smoke was believed by maintenance personnel to have been caused by problems with the APU or the air conditioning air cycle machine.

Throughout the week preceding March 10, Air Ontario maintenance attempted, with limited success, to cure the APU problems. On the morning of March 9, the aircraft was in Toronto and was expected to be operational for a full day's flying. However, that morning Air Ontario maintenance was again trying to rectify the persistent APU problems. After several attempts, maintenance was unable to repair completely the APU, and the aircraft missed its originally scheduled morning flights. In the late afternoon, the pilot-in-command, the maintenance inspector on duty, Air Ontario SOC, and Air Ontario Maintenance Control collectively decided to dispatch the aircraft to Winnipeg and to defer the repair of the APU until the aircraft returned to Toronto on the night of March 10.

This maintenance deferral was carried out pursuant to the company's minimum equipment list (MEL), a document approved by Transport Canada that allows operators to dispatch aircraft with certain items unserviceable (see chapter 16, F-28 Program: APU, MEL, and Dilemma Facing the Crew). Because of the maintenance deferral, the APU would not be used until the problems were rectified.

On March 9, the aircraft was flown from Toronto to Winnipeg via Sault Ste Marie, Thunder Bay, and Dryden. It was parked in Winnipeg overnight, where it received a routine daily inspection by Air Ontario maintenance personnel.

A problem facing Captain Morwood on the morning of March 10 in Winnipeg was that Dryden did not have the ground-start equipment

needed to start the F-28's engines when the APU was unserviceable. As a result, Air Ontario SOC in London notified Captain Morwood in the flight release that he would have to leave one engine running during his Dryden station stops. If for any reason both engines had been shut down in Dryden, they could not have been restarted unless the APU had been started in accordance with the procedures set out in the MEL; a mechanic had been able to repair the APU; or an independent source of compressed air (such as an air bottle) had been transported to Dryden and used for engine startup.

The inability to restart the engines once they were shut down resulted in two significant operational considerations. First, since it was necessary to take on fuel in Dryden, the refuelling had to be carried out with one engine running. This procedure is described as "hot refuelling." Second, the aircraft could not be de-iced at Dryden because a proscription had been published in both a Fokker aircraft winter operations bulletin and an Air Ontario operational directive against de-icing the F-28 aircraft with one or both engine(s) running. It should be noted that Captain Morwood did not request nor was he given any dispensation from this proscription.

Departure from Winnipeg

After his weather briefing on the morning of March 10, 1989, and his receipt of the flight release and other pertinent operational information, Captain Morwood prepared for departure on flight 1362 to Thunder Bay via Dryden.

The flight attendants had noted several deficiencies in the cabin equipment throughout the week preceding the accident. On March 10 the persisting deficiencies or "snags" on C-FONF included missing oxygen equipment, a passenger door that was difficult to close properly, and emergency exit lighting that was not serviceable. The flight crew was aware of these deficiencies in the cabin equipment, and flight attendant Hartwick testified that Captain Morwood expressed frustration that the snags had not been repaired.

In addition to the usual pre-flight checks, Captain Morwood requested that Air Canada ground personnel de-ice C-FONF. The aircraft had been sitting outside overnight and there may have been some frost on the wings.

Air Ontario flight 1362 departed Winnipeg for Dryden at 7:49 a.m. with 11 passengers on board. Although the weather at Dryden was acceptable for the flight, the weather at Thunder Bay was below the captain's landing limits and did not improve during the flight from Winnipeg to Dryden.

Air Ontario SOC requested the Dryden passenger agent[2] to ask Captain Morwood to call SOC when Air Ontario 1362 arrived. The aircraft landed in Dryden at 8:19 a.m., approximately 13 minutes late. The delay was partially attributable to the de-icing in Winnipeg.

First Dryden Station Stop

After landing at Dryden, Captain Morwood left the aircraft to telephone Air Ontario SOC. First Officer Mills remained in the aircraft and, because of the unserviceable APU, the right main engine was left running. The aircraft was not refuelled during this station stop.

At about 8:30 a.m. CST the London SOC duty manager, Mr Martin Kothbauer, advised Captain Morwood by telephone that he was going to hold the aircraft in Dryden pending an improvement in the Thunder Bay weather. The captain reminded Mr Kothbauer that the aircraft engine was running and that they were consuming fuel while they waited. Mr Kothbauer instructed Captain Morwood to call back at 8:45 a.m. CST for further consultation.

At 8:00 a.m. CST Thunder Bay was reported to have an overcast cloud ceiling of 100 feet with a visibility of three-eighths of a mile in fog. When Captain Morwood telephoned Air Ontario SOC a second time, the weather at Thunder Bay was still below his landing limits. Nevertheless, based on an observed trend towards improved weather conditions, alternate fuel requirements, and the aircraft fuel consumption with one engine running, SOC agreed to have Air Ontario flight 1362 depart Dryden for Thunder Bay. It was hoped that the Thunder Bay weather would improve while the aircraft was en route. SOC notified Sault Ste Marie of a possible diversion of the flight, should the weather not improve.

Air Ontario flight 1362 with its 30 passengers departed the ramp at Dryden at 8:50 a.m. CST, 20 minutes late. While en route, the Thunder Bay weather improved, and Air Ontario flight 1362 landed uneventfully in Thunder Bay at 10:32 a.m. EST, approximately 20 minutes late. This concluded the Air Ontario 1362 flight segment. The flight number then changed to Air Ontario flight 1363 for the return trip to Winnipeg via Dryden.

[2] Air Ontario aircraft and passenger handling in Dryden was carried out by their contract agent, the Dryden Flight Centre.

Thunder Bay Station Stop

The flight release issued by Air Ontario SOC indicated passenger loads of 55 from Thunder Bay to Dryden and 52 from Dryden to Winnipeg. The planned alternate was again Sault Ste Marie via Thunder Bay and, in accordance with the flight release, the aircraft was to be refuelled to 15,800 pounds of fuel on board (FOB) prior to departure from Thunder Bay. Altogether, 3310 litres, or about 6190 pounds, of fuel were added. At approximately 11:00 a.m., after the aircraft was refuelled, Air Canada STOC in Thunder Bay advised Air Ontario SOC in London that Air Ontario flight 1363 was overweight. The overweight resulted from Air Canada's STOC having booked 10 passengers from a Canadian Partner flight that had been cancelled earlier in the day onto flight 1363, in addition to the 55 already booked. It appears that Air Canada STOC in Thunder Bay did not inform Air Ontario SOC in London about the change in passenger load in time to allow SOC to inform the flight crew and amend the flight release for flight 1363 with regard to the passenger load and the maximum fuel load.

When faced with this overweight situation, Captain Morwood informed Air Canada STOC in Thunder Bay that he would off-load the additional 10 passengers and their baggage. However, when Air Canada STOC advised the Air Ontario SOC duty manager in London of Captain Morwood's intentions, the SOC duty manager elected to keep the extra passengers on the flight and to make the appropriate weight reduction by off-loading fuel. This defuelling procedure imposed an additional 35-minute delay on the departure of flight 1363 from Thunder Bay. The flight crew was informed of and agreed to the defuelling, and 1510 litres of fuel, or about 2823 pounds, were downloaded from the aircraft, leaving approximately 13,000 pounds FOB.

A number of the passengers on flight 1363 were to make connections out of Winnipeg. During the period from the boarding in Thunder Bay through the station stop in Dryden, many passengers were making inquiries of the flight attendants regarding their connecting flights in Winnipeg. The flight attendants made the flight crew aware of these passenger concerns. Mr Peter Shewchuk, the Air Canada radio operator in Thunder Bay through whom the flight crew was relaying its messages, testified that the flight crew expressed concern regarding the passenger connections. Flight attendant Hartwick also stated that, because of the apparent misunderstanding over passenger and fuel loads and the resulting delay during the Thunder Bay station stop, both Captain Morwood and First Officer Mills expressed anger and frustration. Mr Warren Brown, an off-duty Air Ontario dispatcher, sat in the observer's jump seat in C-FONF and spoke with Captain Morwood and First Officer Mills during the Dryden-to-Thunder Bay leg. Although Mr

Brown described the crew as having been in good spirits prior to landing in Thunder Bay and looking forward to their days off after the flying segment, it is clear from the evidence that their mood changed while they were on the ground at Thunder Bay.

Although Dryden was not a normal refuelling stop, the flight release for flight 1362/1363 anticipated a refuelling in Dryden to 15,000 pounds FOB[3], again with one engine running. This was the so-called hot refuelling procedure.

During the Thunder Bay station stop an amended terminal weather forecast for Dryden, calling for freezing precipitation, was issued. The previous Dryden terminal weather forecast did not. It is normal and prudent procedure that, prior to departure, flight crews operating in instrument meteorological conditions (IMC)[4] check the weather of their destination; and it is mandatory that they check the weather of their alternate. The crew of flight 1363 had access to the Dryden weather forecast via the Air Canada Reservac computer terminal in the Thunder Bay crew room, and they were seen in the crew room during their station stop. It is not known, however, whether in fact they checked the amended forecast.

At 11:55 a.m. EST Air Ontario flight 1363, with 65 passengers and one infant on board, departed Thunder Bay, approximately one hour late. As they approached Dryden, the crew were informed that the runways were bare and dry and that light snow grains had been reported in the previous hour to the west of Dryden. The aircraft landed in Dryden on runway 29 at 11:39 a.m. CST. The flight was approximately one hour behind schedule.

The weather conditions at Dryden on the arrival of flight 1363 were suitable for visual flight rules (VFR) flight. It began to snow lightly when the aircraft landed.

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[3] This refuelling in Dryden was planned. The defuelling which occurred in Thunder Bay had no effect on this aspect of the flight planning.

[4] Instrument meterological conditions (IMC) are cloud and visibility conditions that are lower than required to maintain visual flight. Instrument flight rules (IFR) are rules for the conduct of a flight in weather conditions below those required for visual flight. Visual flight rules (VFR) are rules that provide for flight having continuous visual reference to the ground or water and requiring specified minimum flight visibility. Both IFR and VFR are set out in the Air Regulations.

3 DRYDEN MUNICIPAL AIRPORT AND AIR ONTARIO FACILITIES MARCH 10, 1989

Dryden Municipal Airport

The Dryden Municipal Airport is owned by Transport Canada and is operated by the Dryden Airport Commission on behalf of the Town of Dryden, pursuant to a lease agreement. It is located approximately 6.5 km northeast of the town and is used by scheduled air carriers, a small number of resident aircraft, and one fixed-base operator, Dryden Flight Centre. The Dryden Municipal Airport is also a base for the Ontario Ministry of Natural Resources (MNR). The relationship among the Dryden Airport Commission, Transport Canada, and the various parties operating at the Dryden Municipal Airport will be discussed in chapter 9 of this Report, Dryden Municipal Airport Crash, Fire-fighting, and Rescue Services. A diagram of the airport appears as figure 5-1 in chapter 5, Events and Circumstances Preceding Takeoff.

The aerodrome certificate for the airport was renewed by Transport Canada on March 23, 1988. The last formal Transport Canada inspection of the airport prior to March 10, 1989, was conducted on August 25, 1987. An informal inspection was conducted by Transport Canada on October 19, 1988, and no discrepancies were noted with reference to the department's standards and recommended practices.

Equipment and On-Duty Personnel

The airport maintenance equipment available on March 10, 1989, included two half-ton trucks (one strictly for airport maintenance and one for the airport manager); two snowblower trucks; one front-end loader; two small snowblowers; two runway sweepers; one sand truck; and one chemical spreader (for urea, a chemical used to melt snow and ice on manoeuvring surfaces).

Airport crash fire rescue (CFR) vehicles available on March 10, 1989, included Red 1, a rapid intervention vehicle equipped to deliver water, foam, and dry chemical; Red 2, a crash response vehicle equipped to deliver foam; and Red 3, the fire chief's van, which contained communication radios and limited emergency equipment.

When Air Ontario flight 1363 landed in Dryden on March 10, 1989, on-duty personnel at the Dryden Municipal Airport included the airport manager, Mr Peter Louttit; the CFR chief, Mr Ernest Parry; a CFR crew chief, Mr Stanley Kruger; a fire-fighter, Mr Gary Rivard; the maintenance lead-hand, Mr Christopher Pike; and a mechanic, Mr Allan Haw.

Runways

Runway 11/29 at Dryden Municipal Airport is aligned in a general east/west direction. It is 6000 feet long and 150 feet wide with an asphalt surface. The runway has no appreciable slope. The runway elevation is approximately 1354 feet above sea level (asl). On runway 29 there is a takeoff run available (TORA) of 6000 feet and a takeoff distance available (TODA) of 6200 feet. Air Ontario flight 1363 took off in a westerly direction using runway 29.

In addition to the main runway 11/29, there is a secondary runway, 05/23. This second runway is aligned in a northeast/southwest direction, intersecting runway 11/29 approximately 1250 feet from its eastern end. It has a sand surface and is 2000 feet long and 75 feet wide. Runway 05/23 is not maintained in the winter months.

A single taxiway from the terminal ramp area (taxiway Alpha) enters runway 11/29 approximately 3500 feet from its east end. The airport's two other taxiways are designated taxiways Bravo and Charlie. Prior to March 10, 1989, runway 11/29, which was constructed in 1969, had last been resurfaced in the summer of 1988. It was informally inspected by Transport Canada on October 19, 1988.

On the day of the accident, March 10, 1989, Dryden airport field maintenance staff completed an official daily runway inspection at 4:17 a.m. The runway at that time was reported to be 100 per cent bare and dry. Maintenance was being completed on the runway lights, and various inspections were conducted throughout the morning as workers finished their tasks. The runway condition remained constant. A runway-condition report was passed to the crew of the F-28, inbound from Winnipeg, before their first arrival at Dryden on the morning of March 10.

Approved Runway Lighting

Runway lighting on runway 11/29 consisted of standard runway-identification lights (flashing strobe lights), medium-intensity threshold lights, and runway-edge lights with three intensity-level settings. In addition, runway 29 had 3000 feet of low-intensity centre-row approach lights.

Aerodrome lighting at Dryden is available on request from the Kenora Flight Service Station (FSS). The lights are remotely controlled by Kenora FSS and were available and operable at the time of the accident.

Weather Minima

Canadian domestic airspace is divided into six classes, designated by a single letter A, B, C, D, E, or F, each governed by specific rules. The airspace around the Dryden airport extending five nautical miles from the centre of the airport in every direction to a height of 3000 feet above ground level is designated Class D controlled airspace. As such, aircraft operating under both instrument flight rules (IFR) and visual flight rules (VFR) are permitted to fly in the airspace. On March 10, 1989, the VFR weather minima for the Class D airspace over and around the Dryden airport were visibility of not less than three miles; distance from cloud at least one mile horizontally and 500 feet vertically; and distance above ground level at least 500 feet (except when taking off or landing).

Navigation Aids and Landing Limits

Runway 11 is serviced by a non-directional beacon (NDB) and an instrument landing system (ILS). The NDB minimum descent altitude for runway 11 is 1760 feet above sea level (asl), which is 406 feet above the airport elevation of 1354 asl. The ILS decision height for runway 11 is 1554 feet asl.

Runway 29 is serviced by a localizer back course (LOC(BC)), which has no glide slope, and by an NDB. The LOC(BC) minimum descent altitude for runway 29 is 1780 feet asl. The NDB minimum descent altitude for runway 29 is 1820 feet asl.

Dryden Flight Centre

On December 7, 1987, Dryden Flight Centre Limited entered into an agreement with Air Ontario to provide aircraft, baggage, and passenger-handling services to Air Ontario at the Dryden Municipal Airport. This agreement, which was in effect on March 10, 1989, is silent with regard to the de-icing of aircraft.

Dryden Flight Centre provided the following services and facilities for Air Ontario's aircraft, including the F-28: aircraft marshalling; aircraft refuelling; a ticket counter; a direct-line telephone to Air Ontario System Operations Control (SOC) in London, Ontario; a reservations computer (linked with the Air Canada Reservac computer system); four baggage carts; and a VHF radio capable of communicating with company aircraft and the Kenora Flight Service Station (FSS). For each Air Ontario flight,

Dryden Flight Centre provided one ticket agent and two baggage handlers.

Dryden Flight Centre was also under contract with Imperial Oil Limited as an aviation fuel dealer, and, accordingly, it provided ESSO aviation petroleum products to all aircraft – both general and commercial aviation aircraft – at the Dryden Municipal Airport. As a term of its agreement with Imperial Oil, Dryden Flight Centre agreed to provide training to all personnel involved in fuel handling in order that they be proficient in safe operating procedures. Among the fuelling procedure manuals that Imperial Oil provided to Dryden Flight Centre were ESSO's Aviation Fuelling Guide and ESSO's Aviation Operations Standards Manual.

Mr Lawrence Beeler was the majority shareholder and president of Dryden Flight Centre, and Mr Vaughan Cochrane, a minority shareholder, was the general manager and the fuelling agent.

On March 10, 1989, Mr Cochrane was in charge of the ramp crew. The other member of the ramp crew was Mr Jerry Fillier. The ticket agent on duty was Ms Jill Brannan.

According to the evidence before this Commission, Mr Cochrane received minimal training on F-28 fuelling procedures in the autumn of 1987. Although aircraft-fuelling manuals in the possession of Dryden Flight Centre included instruction on the operation of F-28 main engines and its auxiliary power unit (APU) during fuelling, Messrs Beeler, Cochrane, and Fillier testified that they had no knowledge of such provisions until after the accident.

Further details of the aviation services agreement, particularly with reference to training and procedures related to the fuelling operation, appear in chapter 9 of this Report, Crash, Fire-fighting, and Rescue Services, and in chapter 20, F-28 Program: Flight Operations Training.

Other Services

De-icing

On March 10, 1989, de-icing at Dryden airport was available from Dryden Air Services for any aircraft. Dryden Air Services, a company owned and operated by Mrs Diane Beasant and Mr Mark Beasant, was under contract to provide passenger- and aircraft-handling services for Ontario Express[1] Airlines in much the same way that Dryden Flight ntre

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[1] Ontario Express Airlines, which carried on business as Canadian Partner Airlines and was partially owned by PWA Corporation, was a regional feeder to Canadian Airlines International.

Centre serviced Air Ontario. Ontario Express owned the de-icing equipment and provided the de-icing fluid, while Dryden Air Services employees performed the de-icing.

Dryden Flight Centre did not itself have any de-icing facilities. If an Air Ontario aircraft needed to be de-iced, an employee of Dryden Flight Centre would relay the request to an employee of Dryden Air Services, who in turn would telephone Canadian Partner operations in Toronto to receive permission to de-ice the Air Ontario aircraft. Such permission was never denied. It was understood by the employees of Dryden Flight Centre and Dryden Air Services that, should an Air Ontario and a Canadian Partner aircraft both require de-icing at the same time, Canadian Partner would be given priority. There appears to have been a good working relationship between Dryden Flight Centre and Dryden Air Services, and de-icing was available on short notice.

The de-icing equipment used by Dryden Air Services was manufactured by Mid-Canada Equipment of Winnipeg, Manitoba. The equipment, an "Old Faithful" model, consisted of a spraying mechanism attached to a "bucket" suspended by an articulating arm mounted above a mobile, self-propelled, three-wheeled vehicle. An operator de-icing an aircraft would stand in the bucket and use a control panel to control the movements of the vehicle and the bucket. The spraying nozzle was manually operated.

On March 10, 1989, the average cost of de-icing an aircraft was about $360 but varied according to the amount of de-icing fluid required. Only type 1 fluid was available for de-icing at Dryden.

No one employed by Dryden Flight Centre or Dryden Air Services had ever received any advice or instruction from Air Ontario on procedures for the de-icing of the F-28 aircraft. The training of personnel handling the F-28 aircraft at Dryden is discussed in chapter 20 of this Report, F-28 Program: Flight Operations Training.

Weather Services

Until July 31, 1988, weather information was available through a weather observation facility provided by the Dryden Airport Commission, the authority set up by the town to oversee airport operations. The facility was staffed by trained observers who, in addition to making hourly and special weather observations, maintained a watch of airport activities, communicated with surface vehicles and aircraft on a two-way radio, collected landing fees, and acted as contact persons for pilots of itinerant aircraft. An approved crash alarm system was operated through this facility. Funding for these services was provided by Transport Canada through an annual renewable contract.

In 1988, a public tender was called for the provision of the weather observation services at the Dryden airport. The contract was awarded to Cloud Nine Contracting, which began service on July 31, 1988. Environment Canada's Atmospheric Environment Service personnel provided training for the owners and operators of Cloud Nine, which offered weather-related services only.

Air Traffic Control

Flight Service Station service for the Dryden aerodrome was provided by Kenora FSS via a remote communications outlet. Instrument flight rules (IFR) flights departing Dryden receive their IFR clearance through Kenora FSS. (IFR clearances originate in Winnipeg, the area control centre.) After takeoff, aircraft contact Kenora's en-route radar and other controlling agencies as directed.

In subsequent chapters I will discuss in greater detail the facilities, operations, and services in place at the Dryden Municipal Airport and their significance to the events of March 10, 1989.

4 METEOROLOGICAL INFORMATION

Aviation Weather Information

Canadian aviation weather information is gathered, produced, and distributed by the Atmospheric Environment Service (AES) of Environment Canada with the assistance of contract personnel trained to make weather observations and prepare reports. The weather information is available from a variety of sources to those who require it, primarily aviation planners and flight crew.[1]

Aviation weather information is available from 60 AES weather offices and more than 100 flight service stations (FSS), which are normally located at airports across Canada. Access to this information is available in person, by telephone, and by two-way radio. As well, organizations such as flying schools, corporate aviation departments, air charter companies, and air carriers have computer and facsimile equipment that allows easy gathering of the required weather information.

Types of Weather Information Available

Aviation weather reports (SA), based on hourly weather observations, are issued each hour from over 300 airport and en route stations in Canada. In addition, observations are made and special reports (SP) are issued when weather conditions are fluctuating, or as requested.

Aviation area forecasts (FA) are issued for Canadian domestic airspace and are distributed on a routine basis or when requested. These forecasts are prepared four times a day for 90 regions across the country.

Airport forecasts (FT) are prepared by nine weather forecast offices for 160 airports across Canada. Airport forecasts are limited to airports for which routine hourly (SA) reports are available, as well as special reports that meet AES standards for observations representative for the

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[1] Weather systems are generally large and cover areas in different time zones. As well, because a person can be in one time zone discussing weather in another time zone, the time reference can be confusing. For these reasons, times in this meteorology chapter are in Coordinated Universal Time, which is abbreviated UTC or Z. Z is used in this chapter. Thunder Bay is in the Eastern time zone; EST = Z - 5 hours. Dryden is in the Central time zone; CST = Z - 6 hours. For example: 1800Z is 1:00 p.m. EST at Thunder Bay and 12:00 noon CST at Dryden. The accident occurred at approximately 1811Z.

airport. The forecasts are prepared four times a day and are valid for 12 to 24 hours.

Upper-level wind and temperature forecasts (FD) are prepared for 115 locations in Canada twice a day for three valid periods. Other aviation charts, reports, and forecasts, including weather warnings (significant in-flight weather warning messages or SIGMETS), upper-level prognostic charts, significant weather prognostic charts, radar reports, pilot reports (PIREPS), surface weather charts, and upper level analysis charts are disseminated as required for flight planning purposes.

Significance of Weather Information

All persons who plan flights require weather information for a number of reasons: to make takeoff calculations such as aircraft weight and takeoff speeds and distances; to determine if the visibility is within limits for takeoff; to determine ground speed and time estimates for the flight; to be prepared for en route weather, including turbulence, icing conditions, and storms; to determine if the destination weather is suitable; and to allow the selection of alternate airports where the weather meets regulatory requirements.

When the flight crew of a transport aircraft on a short domestic flight receives a weather package from either its operations centre or a meteorological office, the package will normally contain the following information:

- hourly reports (SA) and special reports (SP) for each en route stop and alternate and, if required, intermediate station;
- forecasts (FT) for each en route airport and alternate and other airports that could be used for an emergency landing;
- upper-level wind and temperature forecasts (FD);
- area forecasts (FA) for the area of the flight(s);
- SIGMETS, PIREPS, and radar reports if applicable; and
- other desired weather information as required or requested by individuals or organizations.

During flight and at en route stops, flight crew continually update their knowledge of the weather that is of significance to them – primarily en route, destination, and alternate weather.

Weather Information for March 10, 1989

Synopsis

The weather surface analysis (figure 4-1) for the area that included Dryden for 1200Z on March 10, 1989, indicated that an arctic cold front extended from central Manitoba to northern Ontario, with a warm front extending south to Duluth, Minnesota. An ill-defined maritime frontal system was also situated over southwestern North Dakota, with a weak centre of low pressure in southeastern Alberta. By 1800Z the arctic cold front had moved southeastward from southern Saskatchewan to the top of James Bay, with the centre of low pressure situated in southwestern Saskatchewan (figure 4-2). The maritime frontal system had moved eastward and was situated over central North Dakota, where a second centre of low pressure was located. Moist air was present over northwestern Ontario, with mid-level instability increasing owing to the overrunning maritime polar air from the northern United States.

General Weather

Broken stratocumulus and altocumulus clouds were present over northwestern Ontario when the accident occurred, at 1811Z, with areas of low cloud and fog producing isolated instrument meteorological conditions (IMC). At 1200Z on March 10, 1989, there were isolated rain showers over southern Manitoba, with a line of scattered thunderstorms over southwestern Manitoba that were moving eastward at 45 knots. At 1700Z radar plots from Vivian, Manitoba, and Upsala, Ontario, showed scattered weak echoes, indicating small storm centres, moving into the Dryden, Ontario, area. SIGMETS were issued by the Winnipeg Weather Office from between 1200Z and 1605Z, valid until 2005Z, based on the radar information about the scattered line of thunderstorms. At 1805Z the Winnipeg Weather Office cancelled the last Sigmet affecting the Dryden area when the radar information indicated that the line of thunderstorms had dissipated into scattered altocumulus castellanus and towering cumulus clouds.

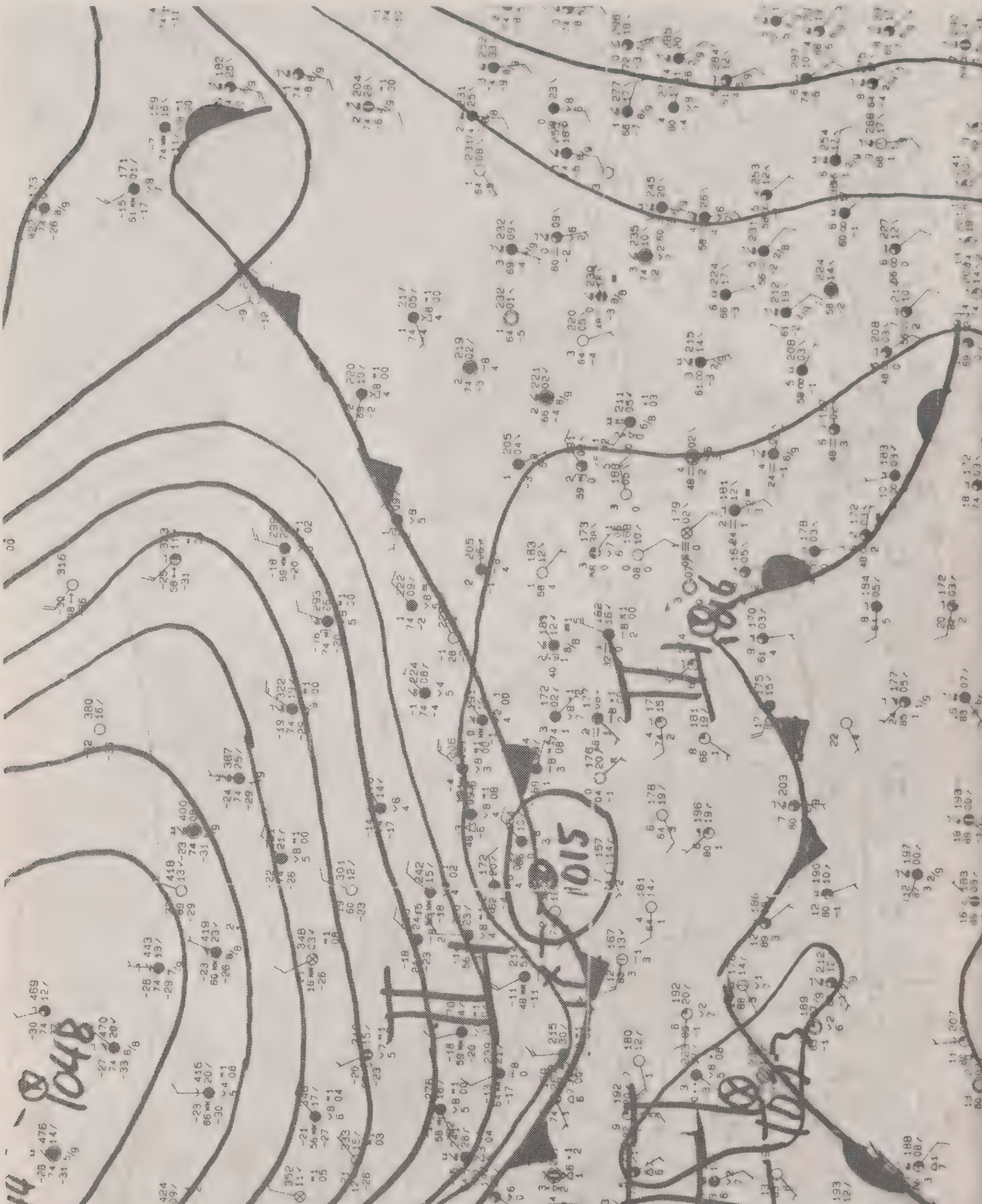
Area Forecast

The area forecast for the area designated as FACN3, which includes Dryden along the southern edge and which was issued at 1130Z and was valid from 1200Z to 2400Z on March 10, 1989, gave the following forecast (not verbatim):

Figure 4-1 Environment Canada, Surface Analysis, March 10, 1989, 1200Z, Prairie Weather Centre

Source: Exhibit 508

Figure 4-2 Environment Canada, Surface Analysis, March 10, 1989, 1800Z, Prairie Weather Centre



Source: Exhibit 509

> Two broken variable to scattered cloud layers based at 3000 feet above sea level (asl) and 8000 feet asl are forecast. Isolated altocumulus castellanus embedded in the layer cloud are expected to give visibilities as low as 3 miles in light rain with a risk of freezing rain. There is a risk of embedded cumulo-nimbus cloud giving visibilities as low as 3 miles in thunder and light rain showers near the end of the period. A few ceilings as low as 300 feet and visibilities down to 1/2 mile are forecast due to patchy drizzle and fog. The freezing level is forecast to be near the surface with an above freezing layer from 2000 feet asl to 6000 feet asl. Light to moderate rime icing is forecast in the cloud above 6000 feet and severe clear icing is forecast in freezing rain. Moderate turbulence is expected near the altocumulus castellanus cloud.

Mr David Patrick, a meteorologist employed by Atmospheric Environment Service of Environment Canada in the Prairie Weather Centre in Winnipeg, prepared a report (Exhibit 313) on weather conditions that existed along the flight path of Air Ontario flights 1362 and 1363 on March 10, 1989. Mr Patrick was also the shift supervisor on duty at the Prairie Weather Centre on that day.

When asked during his testimony about the forecasts for March 10, 1989, in relation to typical March weather in that area, Mr Patrick stated the following:

> A. Well, each March is different, but from my experience, in almost every March if not every March in northwestern Ontario, you can expect to have weather of this nature from time to time, so it is certainly not an everyday occurrence, but in March, there is melting snow and that generates moisture and it forms stratus clouds and fog, so low stratus and fog is – it occurs fairly often in northwestern Ontario in March in the springtime, and low visibilities and ceilings and snowshowers do occur from time to time.
>
> The only thing that was really unusual that day was – really not freakish but unusual – was that there were thundershowers over southern Manitoba that were moving towards northwestern Ontario. That's unusually early in the season to be getting thundershowers.
>
> (Transcript, vol. 49, p. 11)

Winnipeg (YWG) Weather

Winnipeg Forecasts (FT)

The Winnipeg forecast issued at 1045Z on March 10, 1989, and valid from 1100Z on March 10 to 1100Z on March 11 read as follows:

> Ceiling 200 feet, sky obscured, visibility 1/2 mile in fog, occasional sky partially obscured, ceiling 5000 feet overcast, visibility 6 miles in light rain and fog. After 1800Z 600 feet scattered cloud, ceiling 5000 feet overcast, occasional ceiling 600 feet overcast, visibility 2 miles in light rain and fog. After 0200Z [March 11] ceiling 4000 feet broken, 8000 feet broken, occasional sky partially obscured, ceiling 2000 feet overcast, visibility 2 miles in light freezing rain, light snow and fog after 0700Z [March 11].

The amended Winnipeg forecast issued at 1412Z on March 10, 1989, and valid from 1400Z on March 10 to 1100Z on March 11 read:

> Ceiling 500 feet, sky obscured, visibility 1 mile in fog, occasional sky partially obscured, ceiling 5000 feet overcast, visibility 6 miles in thunder and light rain showers. After 1800Z 600 feet scattered cloud, ceiling 5000 feet overcast, occasional ceiling 600 feet overcast, visibility 2 miles in light rain and fog. After 0200Z [March 11] ceiling 4000 feet broken, 8000 feet broken, occasional sky partially obscured, ceiling 2000 feet overcast, visibility 2 miles in light freezing rain, light snow and fog after 0700Z [March 11].

The Winnipeg forecast issued at 1630Z on March 10, 1989, and valid from 1700Z on March 10 to 1700Z on March 11 read:

> Sky partially obscured, ceiling 500 feet broken, visibility 1 mile in fog, variable to 500 feet scattered, ceiling 4000 feet broken, visibility 5 miles in fog. After 2000Z 800 feet scattered, ceiling 4000 feet broken, occasional sky partially obscured, ceiling 800 feet broken, visibility 3 miles in fog. After 0200Z [March 11] ceiling 1000 feet broken, 4000 feet broken, wind 040°T at 10 knots, occasional 5 miles visibility in light snow showers, with a risk of light freezing drizzle. After 1200Z [March 11] ceiling 1500 feet broken wind 360°T at 10 knots.

Winnipeg Reports (SA)

The Winnipeg regular special report (RS)[2] issued at 1200Z read:

> Sky partially obscured, measured ceiling 400 feet broken, 10,000 feet overcast, visibility 3 miles in fog, temperature and dew 0°C, wind 160°T at 7 knots.

---

[2] RS is a regular special (an observation taken on the hour, as is normal, but that reports a significant weather change).

The Winnipeg aviation weather report (SA) issued at 1300Z read:

> Sky partially obscured, 500 feet thin scattered, estimated ceiling 10,000 feet overcast, visibility 2 miles in fog, temperature 0°C, dew point -1°C, wind 160°T at 7 knots.

When Air Ontario flight 1362 departed Winnipeg eastbound at 1349Z (7:49 a.m. CST), the weather at Winnipeg was as indicated at 1300Z.

The Winnipeg SA issued at 1400Z read:

> Sky partially obscured, 500 feet scattered, estimated ceiling 10,000 feet overcast, visibility 2 miles in fog, temperature 0°C, dew point -1°C, wind 150°T at 6 knots.

The Winnipeg SA issued at 1500Z read:

> Sky partially obscured, measured ceiling 700 feet broken, 4300 feet overcast, visibility 1 mile in light rain showers and fog, temperature 1°C, dew point -1°C, wind 300°T at 4 knots.

The Winnipeg SA issued at 1600Z read:

> Sky partially obscured, measured ceiling 500 feet broken, 4500 feet overcast, visibility 3/4 mile in fog, temperature 1°C, dew point 0°C, wind 090°T at 9 knots.

The Winnipeg SA issued at 1700Z read:

> Sky partially obscured, 500 feet thin scattered, 12,000 feet thin broken, visibility 3 miles in fog, temperature 2°C, dew point 0°C, wind 120°T at 10 knots.

The Winnipeg SA issued at 1800Z read:

> Sky partially obscured, estimated ceiling 3500 feet broken, visibility 4 miles in fog, temperature 3°C, dew point 0°C, wind 140°T at 8 knots.

The Winnipeg SA issued at 1812Z read:

> Sky partially obscured, estimated ceiling 1500 feet overcast, visibility 4 miles in light rain showers and fog, wind 120°T at 5 knots.

Between 1812Z and 2200Z the weather at Winnipeg did not deteriorate below sky partially obscured, estimated ceiling 1500 feet overcast, and visibility 3 miles in fog.

Dryden (YHD) Weather

Dryden Forecasts (FT)

The Dryden forecast issued at 1330Z on March 10, 1989, and valid from 1400Z to 2300Z on March 10 read:

> 4000 feet scattered, ceiling 8000 feet broken, occasional sky partially obscured, ceiling 700 feet broken, 4000 feet overcast, visibility 2 miles in light rain and fog.

The amended Dryden forecast issued at 1502Z on March 10, 1989, and valid from 1500Z to 2300Z on March 10 read:

> 4000 feet scattered, ceiling 8000 feet broken, occasional sky partially obscured, ceiling 700 feet broken, 4000 feet overcast, visibility 2 miles in light rain, light freezing rain, and fog.

This was the first forecast specifically calling for freezing rain at Dryden. Aircraft C-FONF was, at the time this forecast was issued, en route from Dryden to Thunder Bay. The aircraft arrived at Thunder Bay at 1532Z.

The Dryden forecast issued at 1630Z on March 10, 1989, and valid from 1700Z on March 10 to 0300Z on March 11 read:

> 3000 feet scattered, ceiling 10,000 feet overcast, occasional ceiling 3000 feet broken, 10,000 feet overcast, visibility 5 miles in light rain, light freezing rain, and fog. After 1900Z 800 scattered, ceiling 4000 feet overcast, occasional sky partially obscured, ceiling 800 feet overcast, visibility 2 miles in light rain and fog, with a risk of thunder and rain showers until 2100Z. After 2100Z ceiling 1500 feet broken, 4000 feet overcast.

This second forecast calling for freezing rain at Dryden was issued while the aircraft was at its Thunder Bay station stop. It departed for Dryden as flight 1363 at 1655Z, 25 minutes after this forecast.

Dryden Reports (SA)

The actual weather reports for Dryden indicated that on March 10, 1989, from 1200Z until 1742Z, the ceiling and visibility did not go below 4000 feet and 12 miles, respectively. Light snow started falling at 1742Z. Aircraft C-FONF landed in Dryden at 1739Z (11:39 a.m. CST).

The Dryden special report (SP)[3] issued at 1748Z read:

> Sky partially obscured, estimated ceiling 4000 feet overcast, visibility 2½ miles in light snow, wind 260°T at 3 knots.

The Dryden SA issued at 1800Z read:

> Sky partially obscured, estimated ceiling 4000 feet overcast, visibility 2½ miles in light snow, barometric pressure 1022.5 hPa (hectopascals), temperature 1°C, dew point –3°C, wind 190° at 3 knots, altimeter setting 30.12″ Hg. (Actual recorded temperature before rounding off was 0.7°C.)

The Dryden SP issued at 1806Z read:

> Precipitation ceiling 300 feet, sky obscured, visibility 3/8 mile in snow, wind 170° at 4 knots.

This was the last weather report issued before aircraft C-FONF commenced its takeoff roll at Dryden at 1809Z (12:09 p.m. CST).

The Dryden SP issued at 1811Z read:

> Precipitation ceiling 1000 feet, sky obscured, visibility 3/4 mile in light snow, wind 170° at 4 knots.

The Dryden accident observation report issued at 1812Z read:

> Precipitation ceiling 1000 feet, sky obscured, visibility 3/4 mile in light snow, wind 170° at 4 knots, barometric pressure 1021.8, temperature –0.3°C, dew point 2.1°C, wind 170° at 4 knots, altimeter setting 30.10″ Hg.

From the above observations, it is apparent that during the 30 minutes that flight 1363 was on the ground in Dryden, the weather deteriorated significantly. By 1806Z (12:06 p.m.), approximately three minutes prior to takeoff, the weather had dropped to a precipitation ceiling of 300 feet, with visibility three-eighths of a mile in snow.

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[3] SP denotes a "special observation." SPs are made when there are specific changes in the observed weather conditions, such as the commencement or cessation of snow, or when requested.

Eyewitness Weather Information for Dryden

A number of witnesses testified about the weather conditions at the Dryden Municipal Airport at the approximate time of the takeoff roll of flight 1363. The evidence shows that, at such time, a heavy snow squall affected the eastern part of the airport, more particularly the area surrounding the button[4] of runway 29.

Observations made by two commercial pilots, Mr Roscoe Hodgins and Mr Craig Brown, and a private pilot, Mr Robert McGogy, all of whom had been flying in the area that day, confirm the above observations. Mr Hodgins is an experienced pilot with about 8000 hours' flight time, and Mr Brown had 1250 hours. Mr McGogy had about 80 hours' flying time.

Mr Hodgins landed at the Dryden airport at 1710Z (11:10 a.m.). During his testimony, he stated that the weather at that time was "good VFR," with no precipitation and very little wind (Transcript, vol. 22, p. 124).

Mr Hodgins taxied to the Ministry of Natural Resources building, located south of the runway, approximately midway between the button of runway 29 and taxiway Alpha. He shut down his aircraft, put the engine heater and cover on, and started to fill up the seed-spraying hopper of his aircraft. These combined tasks took about 10 minutes. While he was filling the hopper, snow began to fall, interrupting his work and prompting him to put wing covers on the aircraft.

Mr Hodgins heard the engines of flight 1363 at 1801Z (12:01 p.m.) and recalled that "[i]t was snowing quite heavy" at that time (Transcript, vol. 22, p. 136). He also saw the Cessna 150, registration C-FHJC, piloted by Mr McGogy, land on runway 29 at 1806Z (12:06 p.m.). He stated that at that time "[i]t was snowing quite heavy" (Transcript, vol. 22, p. 138). Three minutes later, at 1809Z (12:09 p.m.), flight 1363 was at the eastern end of runway 29. Mr Hodgins described the weather and visibility as he observed them when the aircraft began its takeoff roll:

> A. It was snowing quite heavily. I would say the visibility was half to three-quarters of a mile with large, fluffy flakes fluttering down like leaves; you know, they weren't falling straight, they were in a fluttering motion.
>
> (Transcript, vol. 22, p. 140)

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4 The term "button" is often used by pilots when referring to the threshold area of a runway. "Threshold" in general terms defines the beginning of the runway surface which is of sufficient load-bearing strength to allow continual flight operation by aircraft that the runway is intended to serve. In this Report, the terms "button" and "threshold" are both used from time to time when referring to the east end of Runway 29 at the Dryden Municipal Airport.

At approximately 1743Z (11:43 a.m.), Mr Brown reported to Kenora Flight Service Station that he was "down and clear in Dryden." He was questioned on his observations of the weather upon landing:

> Q. ... What was the weather like, more particularly, what was the precipitation like, if any, during your taxi down Alpha and over to the refuelling area?
> A. It – the snow had increased from the snow grains reported earlier to a – more of a heavy snowfall and I am estimating the visibility to be approximately five or six miles.
>
> (Transcript, vol. 5, p. 218)

Mr Brown stated that after landing he proceeded to the fuel pumps located on the Dryden ramp, west of the terminal building, and proceeded to refuel. He estimated he was at the fuel pumps at 11:44 a.m.:

> Q. ... I take it then that you, in fact, commenced to refuel your aircraft, is that correct?
> A. That is correct.
> Q. And how long would that have taken?
> A. Approximately 15 minutes, about 5 minutes before we got the fuelling started and another 10 minutes to finish the fuelling.
> Q. ... If I could take you back to that 15-minute period, I take it you were near your aircraft at all times?
> A. Yes, sir.
> Q. Could you describe the weather, particularly, any precipitation phenomena such as snow and visibility during that 10- to 15-minute period?
> A. As I was saying before, it started to increase, the snowfall, and by that time – by that 15 minutes, it snowed very heavily. With visibility going down to about half a mile at its worst time.
>
> (Transcript, vol. 5, p. 220)

After refuelling, Mr Brown taxied his aircraft to the eastern side of the terminal building to park. He taxied by the F-28:

> Q. ... could you describe the snowfall at that point.
> A. It was still heavy, heavy wet snow. Visibility, again, I think was around a mile to a half a mile.
>
> (Transcript, vol. 5, p. 223)

Mr Robert McGogy, a private pilot, took off about 1720Z (11:20 a.m. CST) on a recreational flight in his light aircraft, a Cessna 150, and flew to the north and west of Dryden, returning to Dryden about 1800Z (12:00 noon). The visibility throughout the flight was poor. On his return leg and close to the Dryden airport, "it was almost a whiteout." As he

approached the airport, the snow increased in intensity and the flakes "were approximately the size of 50-cent pieces, and they were very wet" (Transcript, vol. 22, pp. 25, 40).

Mr McGogy testified that in order to maintain visual reference with the ground, his height above ground level varied from a high of 1000 feet while en route to 150 to 200 feet while approaching runway 29.

At 18:04:03Z Mr McGogy radioed Kenora Flight Service Station and asked: "There any chance that plane [C-FONF] can hold, I'm having real bad weather problems here." At 18:04:07Z, First Officer Mills on flight 1363 transmitted:

> Okay three sixty three's, holding short of the active, be advised you are down to a half a mile or less in snow here.
>
> (Exhibit 7A, p. 31)

Mr Brown heard the Cessna 150's transmissions to Kenora Flight Service Station both on its approach to and after landing at the Dryden airport. He also observed the Cessna 150 taxiing down Alpha taxiway towards the Dryden ramp area. The Cessna 150 reported down at 1806Z (12:06 p.m.) and off the runway onto the taxiway at 1808Z (12:08 p.m.). Mr Brown provided the following observations concerning the weather:

> Q. Could you describe the weather again at the point in time that you saw this 150 taxi in down Alpha?
>
> A. Again, it was still snowing heavily. I'm estimating it to be about half a mile visibility.
>
> (Transcript, vol. 5, p. 225)

Mr Keith Fox, an experienced pilot and F-28 first officer with Air Ontario, was a passenger on flight 1363 from Thunder Bay to Dryden. He testified that at approximately 1804Z (12:04 p.m.) he was driving south from the Dryden airport on Airport Road and saw a Cessna 150 flying north to the airport at an "extremely low altitude" of "no more than 200 feet" (Transcript, vol. 51, p. 189). To be driving south on Airport Road and to see the Cessna 150 flying northward, Mr Fox must have been at least a mile southwest of the button of runway 29. He gave the following evidence regarding the visibility when he observed the Cessna 150 overhead:

> A. I would estimate quarter mile, but it's hard to estimate because it was freezing on my windshield. It was very bad conditions at the time.
>
> (Transcript, vol. 51, pp. 189–90)

Approximately three minutes before the F-28 took off, the airport CFR chief, Ernest Parry, who was located in his vehicle on taxiway Charlie, described a "heavy curtain of snow" and poor visibility when looking towards the east end of runway 29:

> A. ... I realized that I was not even seeing the end of the runway. I was not getting – I could not see the M.N.R. [Ministry of Natural Resources] buildings or towers that were down at that end. I was not seeing that end of the runway.
>
> ...
>
> ...it appeared to be, you know, like a very heavy curtain of snow at that end.
>
> (Transcript, vol. 6, p. 219)

The distance from taxiway Charlie to the MNR buildings is approximately 2000 feet.

Some witnesses in the vicinity of the airport terminal saw smoke from the crash which occurred to the west of the airport. If the smoke they saw was from the fire that started when the aircraft struck the trees on top of the knoll, the distance was about 4500 feet or about seven-eighths of a mile. If the smoke they saw emanated from the crash site, the distance was about one mile. It must be recalled, however, that the heavy snow squall occurred on the east half of the airport, the direction from which flight 1363 commenced its attempted takeoff.

Thunder Bay (YQT) Weather

Thunder Bay Forecasts (FT)

The Thunder Bay forecast issued at 1030Z on March 10, 1989, and valid from 1100Z to 2300Z on March 10 read as follows:

> 600 feet scattered, ceiling 8000 feet broken, occasional sky partially obscured, ceiling 600 feet overcast, visibility 1/2 mile in fog. After 1700Z ceiling 4000 overcast, occasional sky partially obscured, ceiling 1000 feet overcast, visibility 2 miles in light rain and fog, with a risk of light freezing rain.

The Thunder Bay amended forecast issued at 1040Z on March 10, 1989, and valid from 1100Z to 2300Z on March 10 read:

> 600 feet scattered, ceiling 8000 feet broken, visibility 4 miles in fog, occasional sky partially obscured, ceiling 300 feet overcast, visibility 1/4 mile in fog. After 1700Z ceiling 4000 feet overcast, occasional sky partially obscured, ceiling 1000 feet overcast, visibility 2 miles in light rain and fog, with a risk of light freezing rain.

The Thunder Bay amended forecast issued at 1041Z on March 10, 1989, and valid from 1100Z to 2300Z on March 10 read:

> 600 feet scattered, ceiling 8000 feet broken, visibility 4 miles in fog, occasional sky partially obscured, ceiling 600 feet overcast, visibility 1/2 mile in fog. After 1700Z ceiling 4000 feet overcast, occasional sky partially obscured, ceiling 1000 feet overcast, visibility 2 miles in light rain and fog, with a risk of light freezing rain.

The Thunder Bay amended forecast issued at 1043Z on March 10, 1989, and valid from 1100Z to 2300Z on March 10 read:

> 600 feet scattered, ceiling 8000 feet broken, visibility 4 miles in fog, occasional sky partially obscured, ceiling 300 feet overcast, visibility 1/4 mile in fog. After 1700Z ceiling 4000 feet overcast, occasional sky partially obscured, ceiling 1000 feet overcast, visibility 2 miles in light rain and fog, with a risk of light freezing rain.

The Thunder Bay amended forecast issued at 1444Z on March 10, 1989, and valid from 1400Z to 2300Z on March 10 read:

> 100 feet scattered, ceiling 800 feet overcast, visibility 5 miles in fog, occasional ceiling 100 feet sky obscured, visibility 1/4 mile in fog. After 1700Z ceiling 4000 feet overcast, occasional sky partially obscured, ceiling 1000 feet overcast, visibility 2 miles in light rain and fog, with a risk of light freezing rain.

The Thunder Bay amended forecast issued at 1616Z on March 10, 1989, and valid from 1600Z to 2300Z on March 10 read:

> 500 feet scattered, ceiling 10,000 feet broken, occasional sky partially obscured, ceiling 500 feet broken, visibility 1 mile in fog. After 2100Z 2000 feet scattered, ceiling 8000 feet broken, occasional ceiling 2000 feet overcast, visibility 5 miles in light rain, light freezing rain, and fog.

The Thunder Bay forecast issued at 1630Z on March 10, 1989, and valid from 1700Z March 10 to 0500Z on March 11 read:

> 500 feet scattered, ceiling 10,000 feet broken, occasional sky partially obscured, ceiling 500 feet broken, 10,000 feet overcast, visibility 1 mile in fog. After 2100Z 800 feet scattered, ceiling 4000 feet broken, occasional ceiling 800 feet broken, visibility 5 miles in light rain showers and fog, with a risk of freezing rain until 0000Z.

Thunder Bay Reports (SA)

The Thunder Bay SA issued at 1200Z read:

> Indefinite ceiling 400 feet, sky obscured, visibility 1/8 mile in fog, temperature -6°C, dew point -7°C, wind 230°T at 2 knots.

The Thunder Bay SA issued at 1300Z read:

> Sky partially obscured, measured ceiling 400 feet broken, 4500 feet overcast, visibility 1/8 mile in fog, temperature -6°C, dew point -7°C, wind calm.

The Thunder Bay SA issued at 1400Z read:

> Measured ceiling 100 feet overcast, visibility 3/8 mile in fog, temperature -5°C, dew point -6°C, wind 260°T at 2 knots.

The Thunder Bay SA issued at 1500Z read:

> Sky partially obscured, measured ceiling 100 feet broken, 5000 feet overcast, visibility 1/2 mile in fog, temperature -4°C, dew point -5°C, wind 270°T at 2 knots.

The Thunder Bay SP issued at 1521Z read:

> Sky partially obscured, estimated ceiling 300 feet broken, 11,000 feet overcast, visibility 1 mile in fog, wind calm.

The Thunder Bay SP issued at 1547Z read:

> Sky partially obscured, 500 feet thin broken, estimated ceiling 11,000 feet broken, 25,000 feet overcast, visibility 1½ miles in fog, wind 240°T at 2 knots.

The Thunder Bay SA issued at 1600Z read:

> Sky partially obscured, 500 feet thin broken, estimated ceiling 11,000 feet broken, 25,000 feet overcast, visibility 1½ miles in fog, temperature -3°C, dew point -4°C, wind calm.

The Thunder Bay SA issued at 1700Z read:

> Sky partially obscured, 4500 feet scattered, measured ceiling 7000 feet broken, 9000 feet overcast, visibility 1½ miles in fog, temperature -2°C, dew point -3°C, wind calm.

The Thunder Bay regular special (RS) issued at 1800Z read:

> Measured ceiling 8000 feet overcast, visibility 3 miles in fog, temperature 0°C, dew point -3°C, wind 090°T at 3 knots.

Sault Ste Marie (YAM) Weather

Sault Ste Marie Forecasts (FT)

The Sault Ste Marie forecast issued at 0445Z on March 10, 1989, and valid from 0500Z to 1700Z on March 10 read:

> 10,000 feet scattered, high broken. After 0800Z 10,000 feet scattered, high broken, variable ceiling 10,000 feet overcast until 1500Z.

The Sault Ste Marie forecast issued at 1045Z on March 10, 1989, and valid from 1100Z to 2300Z on March 10 read:

> 10,000 feet scattered, high scattered, occasional visibility 3/4 mile in fog. After 1400Z 10,000 feet scattered, high broken. After 1800Z ceiling 10,000 feet broken.

Sault Ste Marie Reports (SA)

Between 1200Z and 2300Z on March 10, 1989, the lowest weather observed at Sault Ste Marie was at 1200Z, when scattered cloud was reported at 600 feet and 10,000 feet, with 10 miles visibility.

Runway Visual Range

General Description

Runway visual range (RVR)[5] in respect of a runway means the maximum horizontal distance, as measured by an automated visual landing distance system and reported by air traffic services (ATS), for the direction of takeoff or landing at which the runway, or the lights or markers delineating it, can be seen from a point above its centre line at a height corresponding to the average eye level of pilots at touchdown.

To compute RVR, three factors must be known: first, the transmissivity of the atmosphere as provided by a visibility sensor; second, the brightness of the runway lights, which is controlled on request by the air traffic control (ATC) controller; and third, whether it is day or night, since the eye can detect lights more easily at night than during the day. During twilight there is a problem, similar to that with prevailing visibility, when neither day nor night conditions prevail.

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[5] Exhibit 607: A.I.P. Canada: Aeronautical Information Publication, section RAC 9.21.1

RVR is measured by a visibility sensor, such as a transmissometer, located near the runway threshold. A light emitted from a source is attenuated in the atmosphere because of snow, fog, rain, and other conditions. The amount of this attenuation, or the transmissivity of the atmosphere, can be obtained by measuring the amount of light reaching a detector after being transmitted by a projector. The visibility sensor samples the atmosphere at a height that best represents the slant transmittance from the pilot's eye at cockpit level to the runway.

Operational Use of RVR

RVR information is available from ATC controllers, control towers, and flight service station (FSS) operators:

> When applicable, RVR information will be passed to the pilot as a matter of routine and may only be used in the determination or application of visibility minima if the active runway is the one served by the transmissometer.
>
> ...
>
> NOTE: RVR reports are intended to provide an indication of how far the pilot will be able to see along the runway in the touchdown zone; however, the actual visibility at other points along the runway may differ due to the siting of the transmissometer. This should be taken into account when decisions based on reported RVR must be made.[6]

In periods of low visibility, large fluctuations can occur during extremely short periods of time. In accordance with International Civil Aviation Organization (ICAO) recommendations, the RVR computer automatically averages the readings over the last minute.

RVR Equipment at the Dryden Airport

The Dryden airport has one set of RVR equipment, consisting of a transmissometer and a sensor, positioned near the threshold of runway 11. The equipment is remotely connected to the Kenora Flight Service Station and is normally controlled from there. The readout is made only in Kenora, not in Dryden. The transmissometer samples a 250-foot path-length parallel to the runway at its west end.

The readout from the RVR equipment is recorded on paper, and only a trained person is able to interpret and calibrate the readout. Mr Brian Sheppard, a senior instrument meteorologist with Environment Canada's Atmospheric Environment Service at Downsview, Ontario, assisted the Commission in interpreting and calibrating the Dryden RVR record. In

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[6] Ibid., section 9.21.3

support of his work, he prepared a report (Exhibit 498) and an amendment (Exhibit 499) to it, and testified at the Commission hearings.

During his testimony, Mr Sheppard provided detailed explanation and support for his calculations of visibility. He also stated that the agreement between the visibility from the meteorological observations at Dryden and the visibility calculated from the RVR information is "well within my experience of such comparisons" (Transcript, vol. 65, p. 114). It must be remembered that the RVR equipment measures the visibility only in the space between the transmissometer and the sensor, while the meteorological observer looks at the entire horizon circle and finds a value that represents the average visibility for that horizon circle.

Visibility Comparisons: RVR and Meteorological Observations
Mr Sheppard provided a chart (Exhibit 499, p. 2) to show the comparison of the visibilities from the RVR and the meteorological observer:

		Observer	
Time	**RVR (Feet)**	**Miles**	**Feet**
1800Z	5000	2 1/2	
1805Z	1400	—	
1806Z	1600	3/8	1980
1811Z	2600	3/4	3960

At the request of the Commission, Mr Sheppard estimated the RVR-derived visibility for 1809Z (12:09 p.m.), the time the attempted takeoff commenced. He estimated that at 1809Z the visibility at the west end of the runway was 2200 feet; however, in making his estimate, he assumed that "some change did not take place in the atmosphere," and that there was continuity in the RVR trace (Transcript, vol. 65, pp. 111–12).

Visibility at Dryden, 1809Z (12:09 p.m.)

Summary of the Evidence
Based on the radio transmission made by First Officer Mills at 1804Z, the visibility in the area of taxiway Alpha at that time was one-half of a mile or less. Based on the testimony of Mr Fox, the visibility south of the airport at about 1804Z was about one-quarter of a mile.

The weather reports indicate that the visibility at the Dryden airport at 1800Z was two-and-a-half miles, at 1806Z was three-eighths of a mile, at 1811Z was three-quarters of a mile, and at 1812Z was three-quarters of a mile. From his vantage point at the airport terminal, Mr Brown estimated that at 1808Z the visibility was about one-half of a mile. The testimony of Mr Hodgins indicates that the visibility at the button of

runway 29 at 1809Z was one-half to three-quarters of a mile, and that as he looked down the runway to the west as the F-28 was taking off, the visibility was about three-quarters of a mile.

Based on the RVR data, Mr Patrick said in evidence that at 1809Z the visibility at the west end of runway 11/29, near the threshold of runway 11, was approximately 2200 feet (between three-eighths and one-half of a mile). At 1812Z the visibility from the terminal to the west, as evidenced by those who saw the smoke, was about one mile.

These close estimates of visibility made by witnesses in the vicinity of the Dryden airport, and the close agreement between witness estimates and the visibilities reported by the meteorology observer and the RVR equipment, are conclusive evidence of the visibility at the time the F-28 started its takeoff roll. The fact that some witnesses saw smoke from the crash fire, about one mile west of the terminal, is not conflicting evidence; their observations were made about two minutes after the F-28 started its takeoff roll, and there is a great deal of evidence that the heaviest snowfall, and hence the lowest visibility, was at the east end of the runway. The position from which the F-28 commenced its takeoff run – the east end of the runway – was approximately 6000 feet from the RVR equipment.

Findings

- The visibility at the button of runway 29 at the Dryden airport at the time the F-28 aircraft, C-FONF, began its takeoff roll, at approximately 1809Z (12:09 p.m. CST), was between three-eighths and three-quarters of a mile.

- The forecast for the area FACN3, which included the Dryden airport, issued at 1130Z on March 10, 1989, and valid from 1200Z to 2400Z, included a risk of freezing rain, with severe clear icing in the freezing rain.

- The Winnipeg terminal forecast issued at 1045Z on March 10, 1989, and valid from 1100Z on March 10 to 1100Z on March 11, as well as the Winnipeg terminal amended forecast issued at 1412Z on March 10, 1989, and valid from 1400Z on March 10 to 1100Z on March 11, forecast occasional light freezing rain.

- The Dryden terminal amended forecast issued at 1502Z on March 10, 1989, and valid from 1500Z to 2300Z, as well as the Dryden terminal forecast issued at 1630Z on March 10, 1989, and valid from 1700Z on March 10 to 0300Z on March 11, forecast occasional light freezing rain.

- All of the Thunder Bay terminal forecasts covering the period on March 10, 1989, from 1100Z on March 10 to 0500Z on March 11, forecast a risk of light freezing rain, occasional light freezing rain, or a risk of freezing rain.

- Based on this weather information and its availability to the flight crew of Air Ontario flight 1362/1363 and the Air Ontario system operations control (SOC) personnel, I find that the flight crew and SOC personnel should have been aware of the fact that the aircraft could be exposed to airframe icing during the station stops at Winnipeg, Dryden, and Thunder Bay on March 10, 1989.

5 EVENTS AND CIRCUMSTANCES AT THE DRYDEN MUNICIPAL AIRPORT PRECEDING TAKEOFF

Air Ontario flight 1363 landed at Dryden on runway 29 at 11:39 a.m. CST. It taxied down taxiway Alpha to the terminal and was marshalled to the front of the terminal by Mr Vaughan Cochrane, the refuelling agent and general manager of Dryden Flight Centre. The aircraft came to a stop, facing west, at the Dryden airport terminal at 11:40 a.m. The centre line of the parked aircraft was approximately 90 feet from the terminal, and the left wing tip was approximately 60 feet from the terminal (figure 5-1).

Between 11:40 a.m. and 12:01 p.m., Air Ontario 1363 was refuelled with the right engine operating and with the passengers remaining on board the aircraft. Eight passengers deplaned in Dryden and seven passengers, two of whom were children, boarded the aircraft.

Condition of Runway on Landing

It was acknowledged by all witnesses that, when the aircraft landed, the runway was bare and wet. Flight attendant Sonia Hartwick described the snow on landing as "big, wet, fluffy snowflakes falling very lightly ... they were drifting down at a little bit of an angle" (Transcript, vol. 10, p. 203).

Mr Richard Waller, a passenger seated in aisle seat 3D (figure 5-2), testified that, on landing in Dryden, it was snowing "big ... very wet snowflakes which melted upon contact with the ground" (Transcript, vol. 18, p. 114). As the aircraft taxied towards the terminal, the snow was light and the weather gloomy and overcast.

Figure 5-1 Dryden Municipal Airport

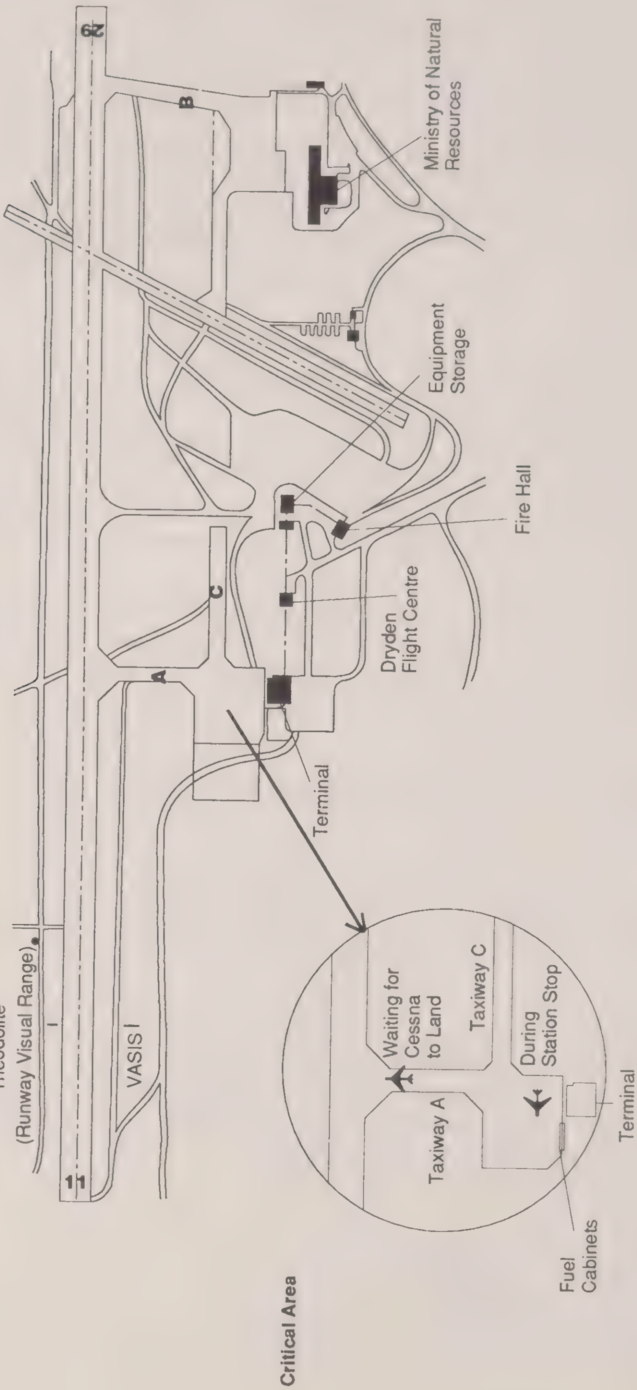
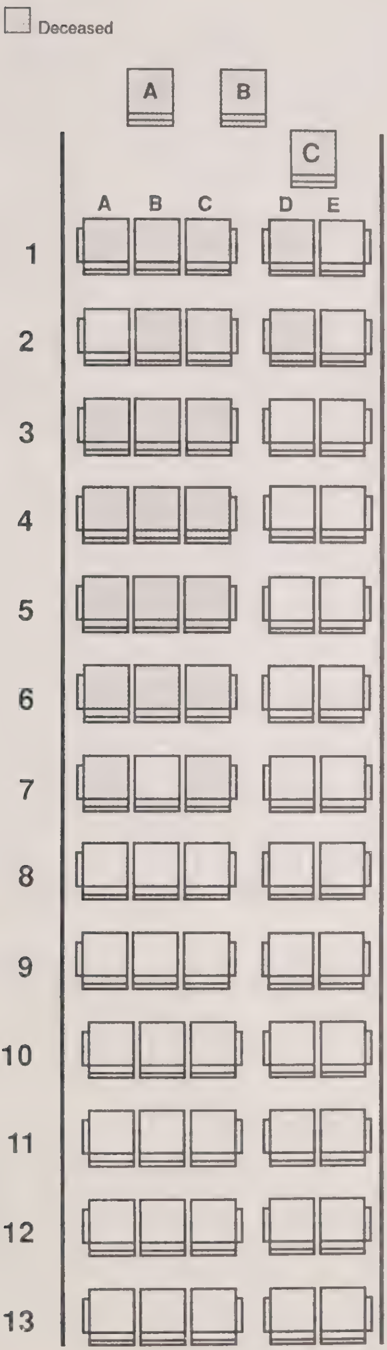


Figure 5-2 Seating Plan of Flight 1363



A Capt. George Morwood
B F/O Keith Mills
C Purser Katherine Say

	A B C	D E
1	Donald Allcorn Pamela Kliewer Brian Kliewer	Steve Syme Karen Syme
2	Uwe Teubert Lisa Kliewer Michael Kliewer	Hilda Rabb Jack Phibbs
3	Ryan Kozak George Kozak Kenneth John McLeod	Richard Waller Clyde Ditmars
4	Wilfred P. McColeman Geraldine McColeman Fred Gallinger	Brian Adams Brian Perozak
5	Mark Monroe William Schweitzer Alvin Rossaasen	Shannon Haines John Archer
6	Donald Finlayson Wendy Fortier Greg Fortier	Gordon Tucker Tina Maronese
7	Rudy Barton Allan MacDougall Nancy Ayer	Ricardo Campbell Shelley Podiluk/ Megan Podiluk
8	Tom Harris Byron Knott Ron Mandich	Flight Attendant Sonia Hartwick Paul Taggert
9	Lori Godin Dan Godin Alfred Bertram	Susan Godin Danielle Godin
10	Donna Menzies Kelly Mackenzie James Mackenzie	Susan Ferguson Michael Ferguson
11	Michael Gatto Ryan Gatto Lois Haines	Violet Woods John Biro
12	David Berezuk Michael Berezuk Sandra Berezuk	Douglas McFarlane Gary Scott McFarlane
13	Gary Jackson Donald Crawshaw Dennis Swift	Murray Haines Jessi Haines

Hot Refuelling

Because the auxiliary power unit (APU) on the F-28 was unserviceable and there was no F-28 ground-start equipment at Dryden, there was no way to restart the main aircraft engines if both were shut down. Therefore, refuelling had to be done while one of the main aircraft engines remained running. This practice, which is commonly referred to as a "hot refuelling," was performed while the passengers remained in the aircraft. Hot refuelling with passengers on board is a highly questionable and unsafe practice. My recommendation that this procedure be prohibited, as contained in my *Interim Report* of November 30, 1989, was accepted and implemented by Transport Canada.

Immediately after the aircraft stopped, Mr Jerry Fillier, an employee of Dryden Flight Centre, brought a baggage cart close to the right side of the aircraft to unload and load baggage. Mr Cochrane assisted him, and then boarded the aircraft at approximately 11:43 a.m. to advise the crew of the baggage count. At this time Mr Fillier was told by a crew member that fuel was required, but he was not advised that it would be a hot refuelling or that any precautions or special steps were necessary to perform the procedure safely. (For a discussion of hot refuelling, see my first *Interim Report*, pp. 23–24, and in this Report chapter 17, F-28 Program: Ground-Start Facilities, and chapter 21, F-28 Program: Hot Refuelling and Ground De-icing.

Mr Cochrane left the aircraft, asked Mr Fillier to bring the fuel truck to the plane, and then went inside the terminal to the Air Ontario desk to call the crash fire rescue (CFR) service unit. According to the Air Ontario Flight Attendant Manual and the ESSO Aviation Operations Standards Manual, the CFR unit was to stand by while any hot refuelling was in progress. The Air Ontario Flight Operations Manual, which was used by pilots and other operational personnel, was silent on the issue of hot refuelling.

At 11:48 Mr Fillier returned with the fuel truck and positioned it near the right side of the aircraft. He then proceeded to the cockpit of the F-28 to find out how much fuel was required. He was told by the captain to bring the fuel up to a total of 13,000 pounds, being 6500 pounds per wing.

Mr Fillier then returned to the fuel truck and hooked up the anti-static bonding cable to the aircraft. He was about to make the connection between the hose and the underside of the right wing when Mr Cochrane instructed him to fuel another aircraft. Mr Fillier advised Mr Cochrane of the amount of fuel uplift required, and Mr Cochrane took over the fuelling of the F-28. He made the single-point connection of the two-inch fuel hose to the underside of the right wing and set the gauges

at the aircraft control panel at the wing root to the amount of fuel requested by the captain.

Mr Cochrane then turned on the fuel flow at the control panel located at the wing root, walked to the fuel truck to open the controls to permit the flow of fuel, and then walked back to the control panel to observe the fuelling operation. From that position he could observe the fuel truck, the single-point fuel entry underneath the right wing, and the aircraft fuel control panel.

It was Mr Cochrane's evidence that he recalled seeing the fire trucks coming along taxiway Bravo to stand by for the hot refuelling; by that time, all the necessary hookups had been completed. From the evidence presented, it is my conclusion that the fuelling process began before the fire trucks actually had arrived and were positioned near the aircraft.

The fuelling was completed at approximately 11:59 a.m. Once the aircraft had received the required amount of fuel, the fuelling process automatically shut itself off at the aircraft. When Mr Cochrane returned to the aircraft to disconnect the hose, a valve in the wing did not close as required, and approximately 5 litres of fuel spilled onto the ramp from the wing-refuelling receptacle.

Mr Cochrane moved the fuel truck away from the aircraft, went into the cockpit to advise the crew that fuelling was completed, and walked towards the terminal, stopping to speak with Mr Stanley Kruger, crew chief of the airport's CFR unit. Mr Cochrane advised Mr Kruger of the fuel spill and was asked if he wanted it washed down by a booster line from one of the rescue vehicles. Mr Cochrane indicated that in his opinion this was not required, and that it would be better to move the aircraft and then clean up the spilled fuel. The fuel spill was washed down by Mr Gary Rivard of the CFR unit after the F-28 left the ramp.

Concurrent Events

At Dryden, Captain Morwood initially stayed in the cockpit while First Officer Mills went to the lavatory in the rear of the aircraft. When the first officer returned to the cockpit, the captain went into the terminal and telephoned Air Ontario System Operations Control (SOC) in London. Mr Wayne Copeland of SOC informed him of the 11 a.m. Winnipeg weather (sky partially obscured, three miles visibility in fog). The captain informed SOC that a short delay would be needed for refuelling and that, if required to proceed to his alternate of Sault Ste Marie, he would proceed directly to it, rather than via Thunder Bay. While the captain was inside the terminal, First Officer Mills, seated in

the aircraft, obtained, via radio, updated en-route and Winnipeg weather from the Kenora Flight Service Station (FSS).

The first officer received the 11 a.m. hourly weather observation as well as updated terminal forecasts at approximately 11:58 CST. During his conversation, at approximately 180030Z (12:00:30 CST), he advised the FSS operator on duty at Kenora that the visibility at Dryden was about one and one-half miles and described the precipitation as "quite puffy, snow ... looks like it's going to be a heavy one" (Kenora FSS taped log, Exhibit 7A, p. 29). Meanwhile, snow was accumulating on the wings. At approximately 12 noon, the captain returned to the aircraft. He walked quickly from the terminal to C-FONF. One witness described his walk as being "in somewhat expedient fashion" (Transcript, vol. 28, p. 21). On boarding the aircraft, the captain, as described by a passenger, "rather looked disgusted ... just not a happy expression" (Transcript, vol. 17, p. 45). No one among the 45 survivors of the crash or the witnesses on the ground observed either pilot do an inspection of the exterior of the aircraft (a walkaround inspection).

Prior to the start of the left engine, Mr Cochrane boarded the aircraft briefly to give the crew the fuel slip. According to Mr Cochrane, Captain Morwood asked if de-icing was available and was told that it was; however, the captain did not request de-icing.

At 12:03 p.m., as Air Ontario flight 1363 taxied for runway 29, the first officer radioed a request to Kenora FSS for instrument flight rules (IFR) clearance to Winnipeg. Immediately after this request, the pilot of a Cessna 150 reported to Kenora FSS that he was four miles south of the airport and inbound for landing. The Dryden weather at 12:04 was below visual flight rules (VFR) limits, and Kenora FSS advised the Cessna pilot that special visual flight rules (SVFR) would be required to land at Dryden. The Cessna pilot requested that Air Ontario 1363 hold while he landed and reported that he was having "real bad weather problems" (Exhibit 7A, p. 31).

Captain Morwood's Call to System Operations Control

As noted in chapter 3, Dryden Municipal Airport and Air Ontario Facilities, on March 10, 1989, Dryden Flight Centre, operating under a contractual arrangement with Air Ontario, provided aircraft and passenger-handling services for Air Ontario at the Dryden Municipal Airport.

The Air Ontario counter was located in the southwest corner of the terminal. The public counter space was equipped with a Reservac computer linked with the Air Canada system, a boarding pass printer, one telephone for normal use, and one direct line telephone to the

security counter in the airport boarding lounge. There was also a VHF two-way communications radio with three dials, to control volume, tuning, and squelch.

On March 10, the first flight to be serviced by Dryden Flight Centre was Air Ontario 1362 during its morning stop between Winnipeg and Thunder Bay. The next Air Ontario flight to be serviced was flight 1363, arriving from Thunder Bay on its return trip to Winnipeg.

The actions of Captain Morwood during the final moments before he boarded C-FONF for the last time were significant to the Commission's investigation into the human performance aspects of this aviation accident. In the course of the investigation, my staff became aware of information that suggested Captain Morwood had a heated conversation over the telephone while he was at the Dryden Airport terminal prior to the departure of flight 1363. A thorough inquiry was conducted into this potentially critical information, and sworn evidence on the subject was elicited from all relevant witnesses. Although there was some inconsistency in the evidence on this subject, I am able to draw some conclusions regarding the demeanour of Captain Morwood during the period immediately preceding the crash. It is, however, necessary to review carefully all the evidence on the subject. I will begin with the evidence of the two individuals who spoke with Captain Morwood on the telephone at the material time.

Evidence of Ms Mary Ward and Mr Wayne Copeland

Ms Mary Ward, the crew scheduler on duty at Air Ontario SOC in London, confirmed that on March 10, 1989, some time between mid-morning and afternoon, she took a telephone call from Captain Morwood, who was at the Dryden terminal. Ms Ward testified that she spoke with Captain Morwood for only a moment and noticed nothing unusual or abnormal about his tone of voice or his telephone demeanour. She stated:

> A. Captain Morwood mentioned the weather had gone down, and as soon as he mentioned that, I put him over to the dispatcher, Wayne Copeland.
>
> (Transcript, vol. 56, p. 118)

Mr Copeland, a dispatcher at Air Ontario SOC, testified that, at about midday on March 10, 1989, he spoke to Captain Morwood for approximately one minute. Mr Copeland stated that they discussed the payload, passenger load, and IFR alternate, and that the captain did not seem upset, in a hurry, or in any way abnormal. Mr Copeland emphatically

stated that there was no heated exchange between him and Captain Morwood. Following the accident, at approximately 2 to 3 p.m. on March 10, Mr Copeland made the following note detailing the content of his conversation with Captain Morwood:

> At approx 1200L (Dryden time) received call from Capt Morwood from Dryden. Morwood and I discussed the fuel load, pax [passenger] load and IFR alternate. At this time I relayed the YWG [Winnipeg] 1700Z wx [weather] which was "-X 5 -SCT 120 -BKN 3F" Morwood then seemed content with the wx and advised that because of the load he would be holding YAM [Sault Ste Marie] direct as the alternate due to load, not YAM via YQT [Thunder Bay] as originally planned. Also mentioned there would be a short delay due fuel being uplifted.
>
> (Exhibit 350)

Mr Copeland, in referring to this note, explained that he had advised Captain Morwood that the Winnipeg weather was as follows: sky partially obscured, a thin scattered cloud layer based at 500 feet, a thin broken cloud layer based at 12,000 feet, with three miles of visibility in fog. This was the extent of Mr Copeland's evidence on the subject of his telephone conversation with Captain Morwood.

Telephone toll records indicate that a telephone call, 1.9 minutes in duration, was placed from the Air Ontario counter at the Dryden airport to Air Ontario SOC at 11:58 a.m. CST. In my view this corresponds with the telephone call described by Ms Ward and Mr Copeland.

Evidence of and Related to Ms Jill Brannan

Ms Jill Brannan, a ticket agent employed by Air Ontario's passenger handler, Dryden Flight Centre, was on duty at the Air Ontario counter at the Dryden airport terminal on March 10, 1989. Ms Brannan testified that she observed Captain Morwood come over to the Air Ontario counter during both station stops on March 10. She testified that she observed and overheard him in telephone conversation with London operations during the morning station stop (i.e., the stop of flight 1362 from Winnipeg to Thunder Bay), but that she had no recollection of his making a telephone call during the second station stop (flight 1363).

Ms Brannan testified that Captain Morwood came into the terminal immediately following the arrival of flight 1363 and that he was on the inside of the counter at the same time she was processing the lost-baggage claims of some passengers who had just deplaned from flight 1363. Ms Brannan testified that she and Captain Morwood discussed the fact that during the captain's telephone conversation with London SOC

on the morning station stop, Captain Morwood had turned off the Dryden Flight Centre VHF radio.

Although Ms Brannan testified that she did not remember Captain Morwood's making any telephone call during the flight 1363 station stop, a number of witnesses gave evidence that Ms Brannan told them that Captain Morwood did make such a call.

Mr Christopher Pike, who worked for the maintenance department at the Dryden airport, testified that Ms Brannan told him that Captain Morwood "had been on the phone and ... was late" (Transcript, vol. 28, p. 52).

Mr Trevor Northcott and Mr Allan Hymers, both of Dryden, testified that they had a conversation with Ms Brannan at the Dryden airport terminal approximately one hour after the crash of C-FONF and that Ms Brannan told them about Captain Morwood's telephone conversation during the station stop. Mr Northcott stated in evidence that Ms Brannan advised both him and Mr Hymers that:

> A. ... when he [Captain Morwood] slammed up the phone, he was certainly upset or disturbed about something.
> Q. And she referred to the phone being slammed?
> A. Yes, she did.
> Q. And did she say anything else about that phone call, sir?
> A. No. She – not that I can recall, that – just assumed that he was – would be talking to Dispatch or Flight Ops or whoever, in the main office, I suppose, in London or –
> Q. Okay. Subsequent to her relating this telephone call to you, did she refer to receiving some radio communication from the pilot of that aircraft?
> A. Yes.
> Q. And would you tell the Commissioner about that, please.
> A. She said it was very unusual but he was talking on the radio. I don't know if she said the captain was talking on the radio, but the – there was two or three calls, and that he still appeared upset or disturbed about something.
>
> (Transcript, vol. 21, p. 113)

Mr Hymers's evidence on his conversation with Mr Northcott and Ms Brannan is as follows:

> A. ... she had told us that he had come in from the flight and he had made a phone call. And her words on the phone call were – she said – she said, I don't know what was said but he was really upset about something.
>
> And then she said he had left and that was about the only thing that he had said to her.

> And I actually don't know what was said to make her get that opinion and he went back to the aircraft.
>
> (Transcript, vol. 21, p. 79)

A final account of the Morwood telephone call came in the testimony of Ms Tara Barton. Ms Barton, a customer-service agent for Canadian Partner Airlines at the Dryden Municipal Airport, testified that at approximately 2:30 p.m., following the crash on March 10, 1989, she spoke with Ms Brannan in the Dryden airport terminal.

> A. ... I had first asked her if she wanted anything and she had said the cup of tea and ... I went over and talked to her for a while at that point.
>
> Q. And what else did you talk about?
>
> A. I had asked her how she was doing, how she was holding up. And she had said that she was worried.
>
> And the word "worried" struck me funny and I asked her, I said, why are you worried. I said, you wouldn't have done anything else for that flight that you wouldn't have done for any other flight, would you. And she said, no.
>
> She explained how the – the day had been unusual or the morning had been unusual from the beginning. She saw the captain come in both off 1362 and again off 1363 and made a phone call.
>
> Q. He made a phone call on just 1362?
>
> A. No, off of both flights.
>
> ...
>
> Q. Did she say anything else?
>
> A. She said that the second phone call had upset him and I told her not to worry about it. I said they can't fault – they are not going to fault you for anything that you have done as long as you have done your job.
>
> (Transcript, vol. 25, pp. 207–208)

Evidence of Captain Keith Fox and Ms Carol Petrocovich

In addition to hearing this "second-hand" evidence regarding Captain Morwood's demeanour in the Dryden terminal, I did hear from two individuals who spoke with Captain Morwood at the material time. Captain Keith Fox, an Air Ontario pilot, and Ms Carol Petrocovich, a court clerk in Kenora, Ontario, were both passengers who had departed from Air Ontario flight 1363 at Dryden. While standing adjacent to the Air Ontario counter at the Dryden terminal, they both spoke with Captain Morwood.

Captain Fox, after returning to the terminal from the airport parking lot, observed Captain Morwood on the telephone. Captain Fox testified:

A. ... I noticed George Morwood was standing at the Air Ontario counter. He was talking on the telephone.
Q. Now, when you say at, was he in front of the counter or behind the counter?
A. He was in front of the counter.
Q. Yes? And what was he doing again?
A. He was on the telephone. And I waved to him, sort of to say goodbye, and he motioned me over, he wanted to talk to me.
And he put his hand over the receiver, and he apologized to me for the delay. He said, sorry about the delay ... but they had us going out of Thunder Bay at – and he named a weight.
And I just did a quick calculation in my head, and I realized that, you know, going out at that weight that he gave me, that would put them over their landing weight in Dryden.
Q. You don't recall what weight he told you?
A. It was – thinking about it, I recall he used something and change. He did say that. But it was well over, you know, the limit. It was obvious from what – the figure he gave me.
...
Q. Do you recall it putting [him] over the maximum takeoff weight?
A. I don't recall that. I just recall – I had other things on my mind, but I recall it was definitely much over the landing weight.
Q. Do you recall the mood of Captain Morwood?
A. At that time, he just seemed more apologetic to me about the delay. And he also – on his P.A. announcement, he apologized for the delay as well on the way up to Dryden.

(Transcript, vol. 51, pp. 184–85)

Ms Petrocovich was at the Air Ontario counter, processing her lost-baggage claim. She testified that an off-duty pilot [Keith Fox] was ahead of her in the line, processing his own claim. She observed the pilot behind the counter [Captain Morwood] initiate a conversation with Captain Fox. Ms Petrocovich testified:

A. The gentleman ahead of me, it became apparent ... because of the conversation that took place that he was an off-duty pilot travelling as a passenger. He was quite concerned about some missing flight bags.
The pilot on the opposite side of the Air Ontario counter initiated some conversation with the gentleman ahead of me. He made a comment to him to the effect, You wouldn't have believed my [weight] in Thunder Bay before we took the fuel off; it was sixty-six and change.

Q. And was there any reply from the other individual in front of you?
A. Just acknowledgement of the comment.
Q. Now, what happened next?
A. The gentleman ahead of me, as I said, was extremely concerned about his missing flight bags. He was pressing the ticket agent to let him go out onto the tarmac and check the baggage compartment of the plane.
She replied with, as long as he had his identification card and put it on, he could go out and look in the baggage compartment. And he left.
Q. Can you describe the pilot standing behind the Air Ontario ticket counter.
A. He was about five-foot-ten, medium build, approximately 180 pounds, dark hair, slightly greying at the temples, dark-skinned, glasses. He wore a white shirt with dark pants ... dark tie, epaulets, approximately early fifties.
Q. Did you notice the demeanour of the pilot behind the counter when he was having his conversation with the individual in front of you?
A. As he was having this conversation with the gentleman ahead of me, he had his ear to the receiver of a telephone the entire time. He was dialling, and it appeared as if he was not getting a response from the other end. He continued dialling –
Q. Before that, what was his demeanour when he was talking to the other individual in front of you?
A. With regard to the comment about sixty-six and change, it was sort of disbelief.
Q. Now, was he on the telephone while he was talking to this individual in front of you?
A. Yes, he – well, he had the receiver up to his ear.
Q. Now, once the person in front of you left the counter, describe what happened then.
A. I started to make my claim with the ticket agent for the missing baggage. As we did so, the pilot spoke to me. He initiated a conversation. He said something to the effect, Oh, don't tell me we have lost your luggage too.
And I said it wasn't really important. He said they had thrown off approximately 10 to 12 bags in Thunder Bay, so, hopefully, it would come that same day.

(Transcript, vol. 26, pp. 10–12)

Ms Petrocovich went on to identify the Air Canada missing baggage report that she and Ms Brannan completed at the Air Ontario counter. Ms Petrocovich, who confirmed that the form was completed at approximately noon, testified that while she and Ms Brannan were completing the form, the pilot behind the counter tried unsuccessfully four or five times to complete a telephone call. She observed the pilot

asking Ms Brannan to confirm the number he was dialling. Ms Petrocovich testified that she recognized the telephone as a local "Oxdrift exchange" number, beginning with the three digits "937." The Dryden airport is included within the Oxdrift exchange, but the Town of Dryden is not. Ms Petrocovich, who did not recall the final four digits of the number, was certain that the pilot dialled a local Oxdrift number and not a Dryden number or a long-distance 1-800 number.

Ms Petrocovich confirmed that the pilot was still behind the Air Ontario counter when she completed her baggage claim and left the terminal. She provided the following evidence on the pilot's demeanour while she was at the counter:

> A. ... there was an element of frustration because he could not complete his telephone call. Other than that ... he initiated a conversation with me and apologized for losing my luggage, and I don't think that falls into the category of a pilot's specifics, handling baggage, and ... I thought that was extremely kind of him, and he was extremely pleasant to me. But, as I said, he was frustrated because he could not complete his telephone call.
>
> (Transcript, vol. 26, p. 18)

When the evidence of Ms Petrocovich is considered, it is apparent that Captain Morwood was attempting to place two telephone calls, one local and one to Air Ontario SOC at London. Although he was unsuccessful in placing the local call, he obviously was successful in placing the call to Mr Copeland of Air Ontario in London. (The confirmed telephone call between Captain Morwood and Mr Copeland of Air Ontario SOC was a 1-800 long-distance telephone number.) It is evident that Captain Morwood attempted to place the local call prior to the call to London. In all likelihood, the 11:58 a.m. call to Air Ontario SOC occurred after Mr Fox and Ms Petrocovich left the Dryden terminal.

It was not possible to determine the party within the Oxdrift exchange whom Captain Morwood unsuccessfully tried to reach. It may have been he was attempting to call the CFR fire hall regarding the hot refuelling and was unsuccessful because the CFR personnel were already en route. (The Dryden CFR fire hall is in the 937 Oxdrift exchange.) Such a theory would, however, be speculation.

Having considered all the evidence regarding Captain Morwood's actions in the Dryden terminal during the flight 1363 station stop, I accept as fact that Ms Brannan did speak with the four witnesses – Pike, Northcott, Hymers, and Barton – about the noon-hour Morwood/SOC telephone call. The next step in assessing the evidence is to determine what weight, if any, can be attached to the substance of the comments Ms Brannan made to these individuals.

I note that much of what Ms Brannan told these four individuals was consistent with other evidence: Captain Morwood did make a telephone call, he was late, two subsequent radio communications were made to the Air Ontario counter by flight 1363, and the first radio communication was a hurried complaint about the additional wait for the Cessna 150. Because of the accuracy of the verifiable portion of what Ms Brannan told witnesses Pike, Northcott, Hymers, and Barton, and the fact that her comments to these individuals were consistent with the overall scenario at the Dryden terminal during the noon-hour station stop of flight 1363, I am prepared to attach some weight to the substance of the four indirect accounts of Captain Morwood's demeanour; and I am satisfied that Captain Morwood was exhibiting signs of frustration while he was in the Dryden airport terminal.

Later Events at the Terminal

Ms Brannan specifically recalled speaking with airport employee Christopher Pike before flight 1363 departed, a conversation corroborated by Mr Pike. Mr Pike testified that before going to the Air Ontario counter to speak with Ms Brannan, he had seen the captain "on his way out the arrival doors in somewhat expedient fashion" (Transcript, vol. 28, p. 21). Since Captain Morwood was on the telephone at the counter until about 12 noon, Mr Pike would have had to arrive at the Air Ontario counter shortly after 12 noon.

While Mr Pike was at the Air Ontario counter with Ms Brannan, two radio transmissions were received from flight 1363. The first transmission was to the effect that flight 1363 would have to wait for an incoming aircraft. Ms Brannan was questioned regarding this first radio transmission:

> Q. And what conversation with the pilot were you referring to?
> A. When he had called me on the radio just before he had taxied out.
> Q. And that was the conversation about having to hold because of the small aircraft; is that right?
> A. Yes.
> Q. That's the conversation where you felt he sounded – describe how you thought he sounded.
> A. I thought he sounded upset.
> Q. And, again, would you tell me why you concluded that this man sounded upset.
> A. Because he was talking really fast, and like, I couldn't really understand exactly what he was saying, just that he was saying

something about an incoming plane and God knows how long we're going to have to wait now.

And I didn't answer back because I didn't know what to say to him. And then, like not even two minutes later, he called back and said that he was going to taxi out now. And I said okay.

Q. He said something like, God knows how long we're going to have to wait now, right?
A. Yes.
Q. And he said that quickly, did he?
A. Yes.
Q. So quickly that you had trouble understanding him?
A. Yes.

(Transcript, vol. 20, pp. 170–71)

The following testimony by Mr Pike regarding the radio transmissions supports the evidence of Ms Brannan:

A. The first radio transmission was to the effect, Looks like we are going to have to wait. I can't believe there is a small aircraft coming in.
The second transmission –
Q. No, let's talk about the first for a moment. Did you gather anything about the way the pilot felt from what you heard on that radio transmission?
A. Yes, I did.
Q. Could you tell us about it.
A. He was very impatient, anxious ... Pissed off.
...
Q. You also heard a second transmission, sir?
A. Yes, I did. He had called in and said that, I see the small plane is down and we are taxiing out.

(Transcript, vol. 28, pp. 22–23)

On the evening of March 10, Mr Pike reduced to writing his recollection of the content of the radio transmission from flight 1363. His written recollection is repeated verbatim as follows:

> Looks like we're going to have to sit a while. I can't believe there's a small plane coming in God knows how long we're going to sit here. I see the small plane is down now and we're going to taxi now. I can't believe there's a small plane coming in God knows how long we're going to have to stay here now. (Talking real fast. Impatient, Pissed off.) I see the small plane's down and we're going to taxi now.
>
> (Exhibit 189)

Mr Pike elaborated upon the content of this note:

> Q. Now, Mr. Pike, the original which I have before me reads, and I quote,
>
> > "I can't believe there is a small plane coming in. God knows how long we are going to have to stay here."
>
> And then you write,
>
> > "Now talking real fast."
>
> What did you mean by that?
>
> A. It was the manner in which he was speaking. It was very quick. It was fast enough that Jill Brannan could not understand what he was saying and I had to repeat it to her.
>
> Q. And the next two words are "impatient, pissed off."
>
> A. Right.
>
> Q. That was the way you sensed –
>
> A. His feeling.
>
> (Transcript, vol. 28, pp. 24–25)

Very soon after the first transmission, a crew member of flight 1363 called back on the radio and said "okay, we're going to taxi out now." Ms Brannan stated that "the second time, he seemed a little calmer" (Transcript, vol. 20, p. 107).

It must be noted that Ms Brannan could not positively identify which crew member was speaking during these two radio communications. Mr Pike, however, expressed a view that it was the captain of the aircraft.[1] Given that it was apparently the task of First Officer Mills to perform the required operational radio communications while the aircraft was on the ground, and that he was in continuous contact with Kenora FSS and the pilot of the Cessna 150 when the Cessna made its final approach and landing, it seems likely that Mr Pike was correct in his assessment that it was Captain Morwood who twice radioed the Air Ontario counter at the Dryden terminal immediately before takeoff.

Role of the Cessna 150 Aircraft

As previously noted, while Air Ontario flight 1363 was preparing to depart from Dryden, a Cessna 150, registration C-FHJS, piloted by Mr Robert McGogy, was inbound to the airport. Mr McGogy, a low-time pilot with a private pilot's licence, had on March 10, 1989, a total of approximately 80 VFR flight hours.

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[1] Because it was not Air Ontario's practice to record aircraft/station radio communications, there was no record of the two communications in question.

On March 10 Mr McGogy had decided to do some recreational flying. He drove from his home in Vermilion Bay to Dryden airport, where his aircraft was parked. Mr McGogy testified that the weather looked "a little bit iffy" (Transcript, vol. 22, p. 14), so he spoke to Mr Cochrane, who advised that "the weather would stay approximately the way it was and within about an hour would probably get worse" (Transcript, vol. 22, p. 17). Following this discussion and after having Dryden Flight Centre refuel his aircraft, Mr McGogy went flying. Figure 5-3 represents the course of his flight, as recalled by him in testimony. The visibility throughout the flight was poor. On his return leg and close to the Dryden airport, "it was almost a whiteout" (Transcript, vol. 22, p. 25). As he approached the airport, the snow increased in intensity, and the flakes "were approximately the size of 50-cent pieces, and they were very wet" (Transcript, vol. 22, p. 40).

In the first of two conversations with Kenora FSS, at 12:03:08, Mr McGogy reported that he was four miles south of the airport, inbound for landing. The FSS operator advised the pilot that the Dryden airport weather was below VFR minima and that he would require a special VFR clearance to enter the zone.[2] Mr McGogy responded that he would be using runway 29, but he did not request special VFR.

Mr McGogy testified that in order to maintain visual reference with the ground, his height above ground level varied, from a high of 1000 feet while en route to 150–200 feet while approaching runway 29.

Based on the evidence of Mr McGogy and his taped radio conversations with Kenora FSS, it is clear that he was a low-time pilot who was in serious trouble. Mr McGogy was already within the five-mile radius of the control zone surrounding the Dryden airport when he contacted Kenora FSS at 12:03. From the evidence it would appear that, when he made this initial communication, the weather was below VFR minima and any SVFR minima.

At 12:04:03 Mr McGogy asked: "There any chance that plane can hold, I'm having real bad weather problems here" (Kenora FSS taped log, Exhibit 7A, p. 31). Flight 1363 then indicated that it would hold.

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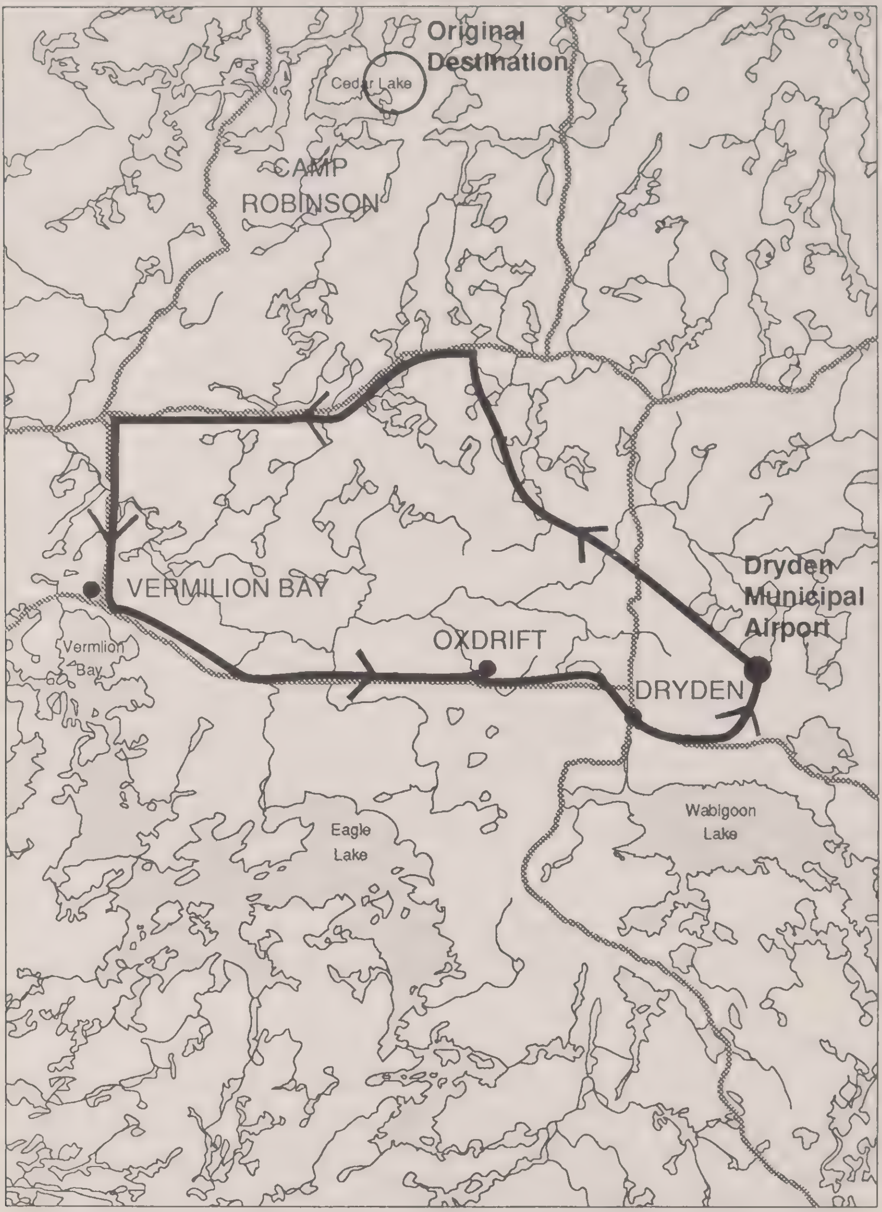
[2] For an explanation of VFR minima, see chapter 3, Dryden Municipal Airport and Air Ontario Facilities. When weather minima are below VFR minima, special VFR flight (SVFR flight) may be authorized by the appropriate air traffic control unit subject to current and anticipated IFR traffic. This authorization is normally obtained through the local tower or FSS and must be obtained before SVFR flight is attempted within a control zone. On March 10, 1989, the applicable SVFR weather minima were as follows: (a) ceiling of not less than 500 feet and ground visibility of not less than 3 miles; (b) ceiling of not less than 600 feet and ground visibility of not less than 2 miles; or (c) ceiling of not less than 700 feet and ground visibility of not less than 1 mile.

Figure 5-3 Flight Path of the Cessna 150



The crew of flight 1363 informed the passengers of the additional delay caused by the Cessna, and at approximately 12:04 a crew member, probably Captain Morwood, called Ms Brannan on the radio to advise that the F-28 would have to hold for a light aircraft.

At 12:04:07, First Officer Mills made the following radio transmission:

> Okay three sixty three's, holding short of the active, be advised you are down to a half a mile or less in snow here.
>
> (Exhibit 7A, p. 31)

Since the crew of the F-28 were aware of what was transpiring in relation to the Cessna, there are several possible explanations of the purpose of First Officer Mills's transmission. In addition to advising both Kenora FSS and the pilot of the Cessna 150 that Air Ontario 1363 would hold and would not proceed onto the active runway, its purpose may have been the following:

- to warn the pilot of the Cessna 150 of the weather at the airport;
- to advise either Kenora FSS or the Cessna 150 pilot, or both, that the weather was below special VFR limits; and/or
- to inform Captain Morwood, indirectly, of the deteriorating weather and the fact that Captain Morwood was below his takeoff limitation.

Mr Keith Fox, a passenger who departed flight 1363 at Dryden and himself an Air Ontario F-28 pilot, testified that when he was driving south from the airport on Airport Road he saw Mr McGogy's Cessna 150 flying north to the airport at an "extremely low altitude ... [of] no more than 200 feet" (Transcript, vol. 51, p. 189). Mr Fox gave the following evidence regarding the estimated visibility at the time he observed the Cessna 150 overhead:

> A. I would estimate quarter mile, but it's hard to estimate because it was freezing on my windshield. It was very bad conditions at the time.
>
> (Transcript, vol. 51, pp. 189–90)

Mr McGogy estimated that he landed approximately 200 feet beyond the button of runway 29. He testified that the runway had approximately one-quarter inch of slush at its centre, with a greater accumulation of slush on the north side of the runway.

After landing at 12:06:42, Mr McGogy contacted Air Ontario 1363 on the radio, asking, "Are you using Runway one one or two nine?" Air Ontario 1363 replied, "We'll go for 29" (Exhibit 7A, p. 33). Having confirmed that the F-28 would be using runway 29, Mr McGogy taxied west, beyond taxiway Alpha, allowing the F-28 to proceed from taxiway

Alpha onto the active runway and to turn right (east) towards the button of runway 29. Mr McGogy then taxied off the runway onto taxiway Alpha and subsequently onto taxiway Charlie, in order to bring his aircraft to its parking location near Dryden Flight Centre.

Five minutes and 53 seconds passed between the time Air Ontario 1363 commenced to hold at the intersection of taxiway Alpha and the ramp and the time it advised Kenora FSS that it was "about to roll" (Exhibit 7A, p. 35). The total time that elapsed up to the actual commencement of the takeoff roll was estimated to be 6 minutes and 4 seconds. A delay of approximately 2 minutes and 45 seconds is attributable to flight 1363 waiting for the Cessna 150 to land.

At 12:07, as flight 1363 taxied for the button of runway 29, the flight crew received their instrument flight rules (IFR) clearance for their flight to Winnipeg. Meanwhile, the snow was continuing to fall heavily, becoming increasingly thick on the wings. When flight 1363 was backtracking towards the button of runway 29, the flight crew lowered the flaps to 18° for takeoff. After turning the aircraft around at the east end of runway 29 they powered up the engine for about 15 seconds before beginning the takeoff roll. The last transmission received from the flight crew, at 12:09:29, was the call, "about to roll twenty-nine at Dryden" (Exhibit 7A, p. 35). The aircraft then started the takeoff roll, approximately one hour and 10 minutes behind schedule.

Eyewitness Observations of Precipitation

Ramp Area

It was acknowledged by every witness who testified on the subject that, during the station stop at Dryden, the ramp area in front of the terminal and where the F-28 waited for Robert McGogy's Cessna 150 to land was, at the very least, wet at all times from falling precipitation.

The ramp area in front of the terminal was black and wet, and, as 12 noon approached, the snowfall's intensity increased and a film of slush began to cover the ramp.

Mr Alfred Bertram, a survivor of the crash and himself a flight service specialist with Transport Canada, was seated in aisle seat 9C and had a reasonable line of vision to the ramp area. Referring to the period when the aircraft initially parked at the terminal, he stated that he "was marvelling at the fact that snowflakes this size (indicating) were actually melting" (Transcript, vol. 18, p. 12).

Mr Ronald Mandich was one of the surviving passengers who boarded flight 1363 in Dryden. He testified as to his observations while boarding the aircraft:[3]

> Q. Now describe boarding the aircraft.
> A. Well, as we left the security area after going through security, I would say that the airplane was approximately 50 to 80 feet from the doorway.
> And as I proceeded with my briefcase in one hand and I flipped my hood on my jacket up over my head because the snow was intense enough so that I figured by the time I got to the airplane, I was going to have a head full of snow and then I would have to deal with that after I got on the airplane ...
> Q. Did you observe any snow or precipitation on the tarmac areas as you walked up?
> A. My recollection is that the tarmac had been scraped from previous snow such that there were bare spots and there were hard packed covered areas. And the snow was sticking to the hard pack snow areas and it was melting on the pavement areas.
> (Transcript, vol. 17, pp. 351–52)

Mr Daniel Godin, seated in 9B, made some critical observations of the ramp on the left side of the aircraft, the area between the aircraft and the terminal. Mr Godin testified that he observed an emergency vehicle standing by during the refuelling and noted that, because of the intensity of the snowfall, the only reason the vehicle could be seen was that it had its headlights and flashing roof lights illuminated. As well, he testified that he saw the refuellers pulling down their toques and pulling up their collars because they were getting covered in wet snow.

In his testimony, Mr Godin stated:

> A. We – as we were sitting there, a dead-style snowstorm hit us, no wind. It started snowing quite heavily.
> I watched the snow hit the side windows of the airplane, immediately turn to water and run down to give us the effect of raining.
> Outside, I had watched the tarmac, and, at all times, you could see asphalt on the tarmac, but it was covered by a layer of thin slush.
> (Transcript, vol. 17, pp. 174–75)

[3] It must be noted that refuelling began at approximately 11:50 a.m., and the passengers who boarded at Dryden embarked before the refuelling commenced.

Two passenger/pilots on board the F-28, Air Ontario Captain David Berezuk and Air Canada Captain Murray Haines, testified about the ramp area in front of the terminal. Captain Berezuk described the area as black and wet. Captain Haines testified that the flakes "melted when they hit the tarmac" (Transcript, vol. 19, p. 15). Captain Haines did not believe it to be snowing at the time he boarded the aircraft at Dryden.

As the aircraft moved away from the front of the terminal to the intersection of the ramp and taxiway Alpha, where it waited for the Cessna 150 to land, the snowfall increased in intensity. According to Mr McGogy's testimony, there was up to one-quarter inch of slush at the intersection by the time the Cessna 150 had passed through taxiway Alpha, this being seconds after the F-28 progressed through taxiway Alpha onto the active runway.

Wings

With the exception of Mr Vaughan Cochrane, every witness who had observed the aircraft wings while the aircraft was parked in front of the terminal testified that the wings were, to some extent, covered with snow, wet snow, or ice.[4] Those who observed the wings while the aircraft was waiting at the intersection of the ramp and taxiway Alpha also testified that the wings were, to some extent, covered with snow.

While the F-28 was standing in front of the terminal, a number of revealing observations were made. Mr Michael Ferguson was seated in 10E, a window seat with a direct unobstructed view of the right wing. He stated that the amount of snow covering the wing was such that he "couldn't see ... the line of rivets on the wing" (Transcript, vol. 13, p. 15).

Mr Gary Jackson was seated in 13A, a window seat with a direct line of vision to the left wing. He recalled that during the time the aircraft was at the terminal, the snow was "slowly but steadily increasing." He stated that snow was collecting on the wing and that "[a]t the terminal, between 5 and 10 per cent of the wing would have been covered" (Transcript, vol. 16, pp. 125, 126). He was able to see the metal on the wing through the snow.

Mr Ricardo Campbell was seated in 7D, an aisle seat directly over the wing. He stated that, while waiting at the terminal prior to the aircraft taxiing for the first time, he observed "straight ice" on the right wing. "There was a glaze," he said (Transcript, vol. 17, pp. 46, 47). Air Ontario Captain David Berezuk was seated in 12A, a window seat with a direct line of vision over the left wing. He stated that, just before the aircraft taxied out, he looked at the wing and saw a trace of snow covering all of the wing. He estimated that this trace of snow, at the highest point,

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[4] See my first *Interim Report*, pp. 24-25.

was approximately one-quarter inch thick. Referring to the distribution of snow over the wing, Captain Berezuk said that at its highest point the snow "was sort of a texture of a sculptured carpet" (Transcript, vol. 14, p. 55).

Mr John Biro was seated in 11E, a window seat directly overlooking the wing. He stated that the snow on the wing was melting, but not as rapidly as it was falling, and that there was an accumulation of snow on the wing. At the time the fuel truck was by the aircraft the accumulation was, he believed:

> A. ... about between an eighth and a quarter of an inch accumulation. And it seemed to stay about that way throughout the refuelling process because it was melting next to the wing and the new snow was landing on top of the wet, melting snow.
>
> (Transcript, vol. 21, p. 9)

Air Canada Captain Murray Haines, who was seated in 13D, testified that he had a good view of the right wing:

> A. ... the first large snowflakes fell and they fairly adhered themselves to the wing. As they touched the wing, they melted a bit and adhered to the wing.
>
> (Transcript, vol. 19, p. 15)

Flight attendant Sonia Hartwick stated that she looked at the wing while the aircraft was parked in front of the terminal, and that there was "a fluffy layer of snow on the wing" (Transcript, vol. 10, p. 218).

Similar observations of snow accumulation on the wings, while the aircraft was standing in front of the terminal, were also made by firefighter Gary Rivard, who was attending to the hot refuelling, and by Ms Cherry Wolframe, an employee of Dryden Air Services, who was inside the terminal.

Observations of Mr Vaughan Cochrane

The only eyewitness to testify that he did not see any snow on the wings while the aircraft was in front of the terminal was Mr Vaughan Cochrane. Mr Cochrane had initially boarded the F-28 to give the baggage count to the crew. It will be recalled that he refuelled the aircraft, and then spoke with Mr Stanley Kruger about the fuel spill.

At approximately 12:01, Mr Cochrane boarded the aircraft for a second time, to advise that the fuelling was complete. His observations of the events surrounding the crash were recorded by him in a prepared statement, drawn up at approximately 3 p.m. on the afternoon of the crash. This statement contains in my view three noteworthy items:

- On start up commenced snowing heavy wet snow ...
- A/C was taxiing before any build-up on wings ...
- My impression are undecided however I do not feel icing was heavy or sustained to be a major factor ...

(Exhibit 415)

As noted earlier, while Captain Morwood was in the terminal, First Officer Mills was checking the weather with Kenora FSS. First Officer Mills made the following transmission from the aircraft to Kenora FSS at 12:00:30:

> Okay we check that, we're down to about a mile and a half in Dryden in snow right now, quite puffy, snow, looks like it's going to be a heavy one. Uh, okay and go ahead the rest.
>
> (Exhibit 7A, p. 29)

This radio transmission was apparently made by First Officer Mills before Mr Cochrane boarded the F-28 for the second time to give the crew the fuel slip.

In view of this radio transmission, Mr Cochrane was asked to recall the snowfall at that time:

> Q. ... would you like to reconsider your own recollection of what the snowfall was like when you boarded the aircraft which would have been, in all probability, after that point in time?
>
> A. No, I think that's consistent with a light to moderate snowfall. He [Keith Mills] of course, from his perspective, was looking out to the west and could see the approaching weather.
>
> Q. So you would not disagree that it was puffy snow that was falling at that time?
>
> A. No, I wouldn't disagree with that.
>
> (Transcript, vol. 53, pp. 159–60)

Following the crash, Mr Cochrane gave two interviews to Mr Guy Dutil of the Canadian Aviation Safety Board (CASB). In his first interview, on the morning of March 11, 1989, Mr Cochrane recalled what he observed when he was in the aircraft to advise that fuelling was complete:

- ... I gave the pilot his final uplift ... at that point it had started to snow fairly heavy wet snow.

- ... we gave him the O.K. to depart because it was snowing heavy they closed the door right off quick.

- Marshalled them off the gate and he departed the gate. There was no significant accumulation of snow on it.

- When it was sitting on the ramp during the turn around that – that airplane was clean. It started to snow on it about the time we started closing it up.

(Exhibit 414[a], pp. 3, 8)

In his second interview with Mr Dutil, on March 14, 1989, Mr Cochrane described coming out of the cockpit after the fuel uplift was given:

- I marshalled the aircraft off the gate, toward the taxiway. The question is about snowing, or was about snowing. It had started very, very light snowfall as I was coming down from out of the cockpit. As the aircraft turned to taxi, it was snowing very, very lightly.

- In my mind there was no question at that point about de-icing the aircraft, there was just no significant accumulation of snow on the airplane.

- ... when that airplane left the ramp, it was ready to go flying. It hadn't snowed enough to create an accumulation.

- The snow had not started when he had marshalled off the ramp or was so light as to be insignificant ...

(Exhibit 414[b], pp. 3, 7, 9)

Mr Cochrane, when questioned on the obvious discrepancy in the two statements that he gave CASB regarding the intensity of the snowfall, explained:

A. I would have to say that the first interview with Mr Dutil was probably the most current and would probably represent the best information.

(Transcript, vol. 54, p. 173)

When he was questioned before the Commission, Mr Cochrane was presented with the observations of witnesses describing the snowfall and condition of the wings while the aircraft was parked in front of the terminal. In view of the consistent nature of the observations made by other eyewitnesses, Mr Cochrane's contrary evidence was challenged. He stated that his observations of the aircraft wings were restricted to those made from the stairs of the aircraft, and he conceded that the other witnesses, who were sitting in the aircraft, looking out at the wings, would have had a better view. I have no hesitation in concluding that

the evidence of the other witnesses correctly reflects the condition of the wings of the aircraft while it was on the ramp.

Waiting for the Cessna 150

When the aircraft departed from in front of the terminal, it moved to the intersection of the ramp area and taxiway Alpha, where it waited for the Cessna 150 to land and clear the active runway. A number of observations made by witnesses aboard the aircraft reveal the effect of the deteriorating weather conditions on the wings.

Air Ontario Captain David Berezuk, who from his vantage point in seat 12A was able to see the left wing, acknowledged that the snow was accumulating and staying on the wing.

> Q. And what did you see?
> A. I saw snow accumulation on the left-hand wing wet in texture and, again, like a sculptured carpet.
> Q. And how much snow was accumulating?
> A. At what time?
> Q. When the aircraft was parked on the taxiway just prior to Alpha.
> A. Approximately quarter of an inch.
> Q. It was a quarter of an inch. Now, you said it was a quarter of an inch by the terminal approximately?
> A. That is correct.
> Q. Now when it taxied out and stopped just prior to entering taxiway Alpha, how much – how thick was the snow?
> A. It was more than one quarter of an inch at that time due to the increasing snow.
> Q. And was it adhering; was it staying on the wing?
> A. Yes.
>
> (Transcript, vol. 14, pp. 59–60)

In response to further questioning, Captain Berezuk provided evidence of his additional observations to the effect that up to one-half inch of snow had accumulated on the wings while flight 1363 waited at the intersection for the Cessna 150 to land:

> Q. And at the end of the five minutes as the aircraft was sitting there, did you observe the left wing?
> A. Yes.
> Q. And did you observe the right wing?
> A. Yes.
> Q. And can you tell me what the weather conditions were like at the end of the approximate five minutes?

> A. At the end of the five minutes, the portion of the left wing, of which I stated I could see, was varying in amounts up to one half an inch at that time.
>
> (Transcript, vol. 14, pp. 61–62)

Mr Michael Ferguson, from his vantage point in seat 10E, made the following observation:

> A. ... The wing was covered with snow. I remember saying to my wife to look at the wing ...
>
> (Transcript, vol. 13, p. 17)

Mrs Susan Ferguson corroborated the evidence of her husband, Mr Michael Ferguson.

Ms Kelly Mackenzie, seated in 10B, a vantage point close to the centre of the wing, described what she saw on the wing of the aircraft:

> A. ... I was noticing that white was starting to cover the wings at this point ... it was just building up to a white colour. That's what I saw.
>
> (Transcript, vol. 19, pp. 185–86)

Mr Brian Perozak was seated in window seat 4E. Looking over his right shoulder while the aircraft waited for the Cessna to land, he observed "up to a half an inch of fluffy snow on the wings" (Transcript, vol. 16, p. 229).

Flight attendant Sonia Hartwick also testified that, while waiting for the Cessna 150 to land, "there was a layer of fluffy snow on the wing" (Transcript, vol. 10, p. 228).

Findings

Landing at Dryden

- Air Ontario flight 1363 landed in Dryden on March 10, 1989, in visual meteorological conditions. When the aircraft landed, the runway was bare and wet. Light snowflakes that melted upon contact with the tarmac were falling when the aircraft taxied to the Dryden terminal.

At the Dryden Terminal

- While passengers were leaving and boarding the aircraft, the snowfall was steadily increasing in intensity. Initially, snowflakes were melting on contact with the tarmac, but, by the time the aircraft was about to

leave the terminal, at approximately 12:01 p.m., a thin film of slush was covering the ramp.

- While at the Dryden terminal, the aircraft was refuelled. Because the auxiliary power unit on the F-28 was unserviceable, it was necessary to keep one engine running during the refuelling. This practice, which is commonly referred to as a "hot refuelling," was performed while the passengers remained in the aircraft and in all probability commenced before the required fire trucks were in place.

- Hot refuelling with passengers on board is a highly questionable and unsafe practice that was contrary to the provisions of the ESSO Aviation Operations Standards Manual and the Air Ontario Flight Attendant Manual.

- During the refuelling procedure, Captain Morwood went into the airport terminal while First Officer Mills remained in the aircraft.

- Captain Morwood unsuccessfully attempted to place a local telephone call from the Air Ontario counter at the Dryden airport terminal. While he attempted to place this telephone call, Captain Morwood spoke with Captain Keith Fox and Ms Carol Petrocovich. Captain Morwood apologized to Captain Fox for the delay of flight 1363 and explained that, in Thunder Bay, "they" (presumably Air Ontario System Operations Control (SOC)) had put the flight well over its maximum landing weight at Dryden. Captain Morwood apologized to Ms Petrocovich regarding her lost baggage.

- Captain Morwood showed signs of frustration when he was unable to complete his local telephone call.

- After failing in his attempt to place the local call, at 11:58 a.m., Captain Morwood telephoned Air Ontario SOC, speaking with Ms Mary Ward and then Mr Wayne Copeland. Captain Morwood advised Ms Ward that the weather at Dryden had deteriorated, and he discussed fuel and passenger loads and the Winnipeg weather with Mr Copeland.

- Ms Brannan of Dryden Flight Centre was in a position to observe and/or overhear Captain Morwood making this telephone call. Although Ms Brannan stated that she had no recollection of speaking with anyone about the telephone call, I am satisfied by the evidence of witnesses Pike, Northcott, Hymers, and Barton that she did advise them of such a telephone call.

- Although Mr Copeland and Ms Ward stated that Captain Morwood was not upset when they spoke with him, they were not in a position to observe his demeanour following his telephone conversation. I am satisfied that, in the Dryden terminal before and after the SOC telephone call, Captain Morwood was exhibiting signs of frustration and of being in a hurry.

- Captain Morwood left the terminal in a hurried fashion after he completed his telephone call to Air Ontario SOC.

- On boarding C-FONF at approximately 12 noon, Captain Morwood seemed troubled and did not have a "happy expression."

Accumulation of Snow on the Wings while Aircraft at Gate

- Snow continuously accumulated on the wings of the aircraft throughout the station stop. When the aircraft was about to leave the terminal area, at approximately 12 noon, its wings were covered in snow to depths varying from one-eighth to one-quarter of an inch.

- Ground handler Vaughan Cochrane was in a position to observe the wings prior to the aircraft's leaving the terminal area, and he knew, or ought to have known, that the wings were covered in snow. Captain Morwood asked Mr Cochrane whether de-icing was available, and Mr Cochrane indicated that it was. There was no follow-up to this inquiry by either Captain Morwood or Mr Cochrane.

Waiting for the Cessna 150

- As the F-28 was about to proceed onto the runway, it was unexpectedly subject to a delay, of approximately 2 minutes and 45 seconds, while, in heavy snow and poor visibility, a Cessna 150 aircraft landed.

- The pilot of the Cessna 150, Mr Robert McGogy, was not instrument rated. He was already within the five-mile radius of the control zone surrounding the Dryden airport when he first contacted Kenora FSS at 12:03:08 p.m. It would appear that, when he made this initial communication, the weather was below VFR minima and any SVFR minima.

- During this delay, a pilot from flight 1363, in all likelihood Captain Morwood, radioed back to the Air Ontario counter at the Dryden airport and, in a hurried, impatient manner, said to the Air Ontario

ticket agent something like: "I can't believe there is a small plane coming in. God knows how long we are going to have to stay here."

- At approximately the same time, Captain Morwood made a public address announcement to the passengers, explaining the reason for the delay.

- A short time later, Captain Morwood radioed back to the Air Ontario counter and, in a calmer tone, advised the Air Ontario ticket agent that the small plane had landed and that flight 1363 was about to taxi out.

- During the delay created by the Cessna 150, the snowfall increased in intensity such that visibility was reported by First Officer Mills at 12:04:07 p.m. to be one-half mile or less.

- During the delay, the accumulation of snow on the aircraft wings increased to an uneven depth of one-quarter to one-half inch.

- At the time the F-28 entered the runway and began back-tracking to the button of runway 29 (approximately 12:07:00 p.m.), there was an accumulation of approximately one-quarter to one-half inch of slush on that portion of the runway.

6 CIRCUMSTANCES RELATED TO THE TAKEOFF AND CRASH OF FLIGHT 1363

The Takeoff Roll – Condition of Aircraft

At 12:09:29 p.m., a flight crew member of flight 1363 advised Kenora Flight Service Station (FSS) that they were "ready to roll." The estimated time of commencement of the takeoff roll is 12:09:40 p.m.

A number of telling observations regarding weather conditions just prior to takeoff and during the takeoff roll were made by surviving passengers. Flight attendant Sonia Hartwick testified that the snowfall intensified, particularly from the time the aircraft left the terminal to the time it arrived at the end of the runway in preparation for takeoff. Her observations as to the transformation of snow to ice during the takeoff roll were vivid:

> Q. Now, you're rolling down that runway, and what are you looking at?
> A. I'm staring at the wing.
> ...
> Because, at this time, as we rolled down the runway, the snow was now turning to ice on this wing, it was freezing to the wing.
> Q. Now, let's stop there and go over this in some detail. If you're rolling down the runway, you, up to that point in time, have observed this layered, fluffy buildup of snow, and what happened to that layered, fluffy buildup of snow as you were rolling down the runway?
> A. It crystallized and turned to ice.
> Q. Describe to me what you saw.
> A. At first, it was frosty, and then it turned clear, and then it was now the color of the wing and you could see a sheen on it, that it was actually ice on the wing.
> Q. So you could see the transformation?
> A. Yes, you could definitely see the transformation. It happens very quickly.
>
> (Transcript, vol. 10, pp. 239–40)

Mrs Hartwick's evidence on the witness stand, as to the condition of the wing on takeoff, was consistent with a tape recording of her telephone conversation with Mr Clifford Sykes, then the director of flight operations at Air Ontario, which took place between 1:15 and 1:30 p.m. on March 10, 1989, approximately one hour after the crash. Mrs Hartwick was not aware that her telephone conversation with Mr Sykes had been tape recorded by him, and the existence of the tape was discovered by Commission staff only by chance in early August 1989 and the tape itself was eventually obtained by Commission investigators in September 1989. The relevant portion of the transcript of this tape recording reads as follows:

> Sonia: And uhm, the wings were icing up.
> Cliff: They were? After take off or before?
> Sonia: Uhm, before take off there was quite a bit of wet snow on them, as we were taking off it was freezing.
>
> (Exhibit 126)

Mr John Biro, from his observation point in seat 11E, directly above the wing, stated:

> A. We started to roll down the runway and at this stage I was looking at the wing rather closely, hoping that as we gained speed this wet snow would slide off.
>
> We reached flying speed at seemingly about the same time as previously. And as the nose of the aircraft lifted, the snow on the back part of the wing, about halfway up across the wing, came off with a puff, almost an explosive-type puff.
>
> And the snow on the forward part of the wing seemed to freeze to an opaque, dull opaque ice, almost a flash freezing type thing. And it had a rough surface, not – not coarsely rough but definitely a rough surface.
>
> (Transcript, vol. 21, p. 12)

David Berezuk, an Air Ontario Dash-8 captain, from his window seat in row 12, observed a half-inch "wet snow accumulation" on the left wing as the aircraft was taxiing towards the button. He described the snowfall as "increasing in intensity from the time we arrived at the terminal until the whole takeoff phase" (Transcript, vol. 14, pp. 79–80).

As the aircraft was on its takeoff roll, Captain Berezuk noted the snow on the wing changed in colour from white to an opaque grey, dissipated in thickness, and took on a sculptured carpet texture:

> A. ... As we gained forward speed approximately 10 to 20 percent, in my best assumption, 10 to 20 percent of the snow had blown off the wing.

Q. Did you see that snow blow off?
A. It is not really a question of seeing it blow off, I saw it dissipate.
Q. When you say "dissipate," did the thickness of the snow on the wing just decrease?
A. Yes.
Q. Did it change in colour at all?
A. Yes.
Q. Can you tell me what that colour was?
A. The parts where it was sculptured, again, I explained that it was a sculptured carpet texture, the parts that were white in colour got more of a greyish opaque colour and the parts that were greyish got more grey in intensity.

(Transcript, vol. 14, p. 84)

As the F-28 was taxiing towards the button in preparation for takeoff, Captain Murray Haines, an Air Canada pilot seated in an aisle seat in row 13, described what he could see of the wing as "thoroughly covered in wet snow" with a rough texture.

He further specified:

Well, I could see the root of the wing. I couldn't see the leading edge. But, as much as I could see, it was covered in snow.
Q. And was it a very smooth cover that you observed or was it –
A. No, it was a rough texture.
Q. Rough texture, okay. And was it – while you were taxiing, was it blowing off or falling off?
A. No, it wasn't.

(Transcript, vol. 19, pp. 34–35)

Captain Haines then testified that, on the plane's final takeoff roll, he observed that the snow on the wings was not moving off and he saw it crystallize to ice:

A. ... as the speed got up, the snow crystallized into ice, and it wasn't moving off the wings.
Q. You saw the snow crystallize to ice?
A. Yes, I was watching it all the time.

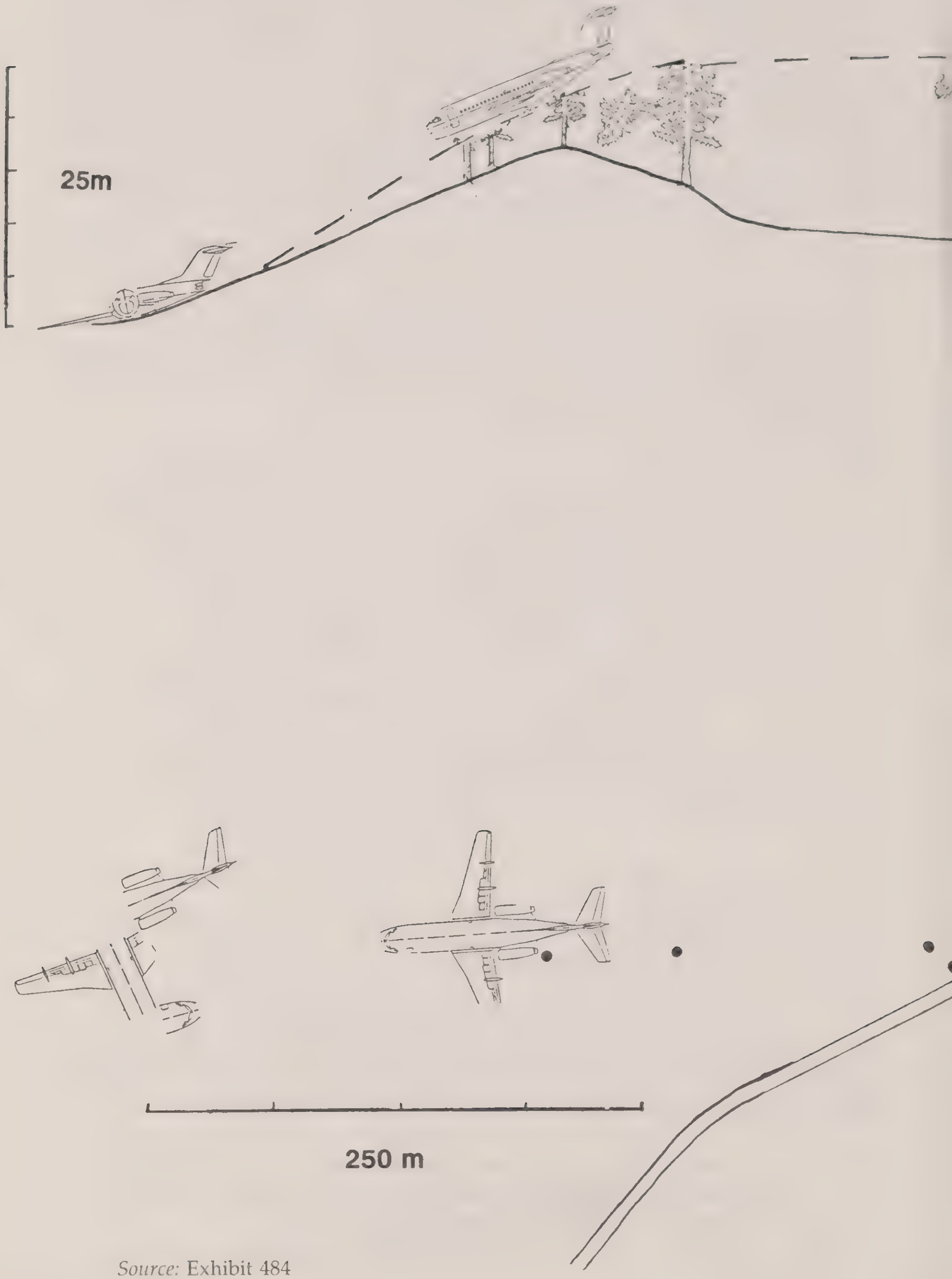
(Transcript, vol. 19, p. 37)

In testimony, passenger Brian Perozak, seated in 4E, described the front edge of the wing on the takeoff roll as looking like "a glazed donut." He described the rest of the wing as crystallized:

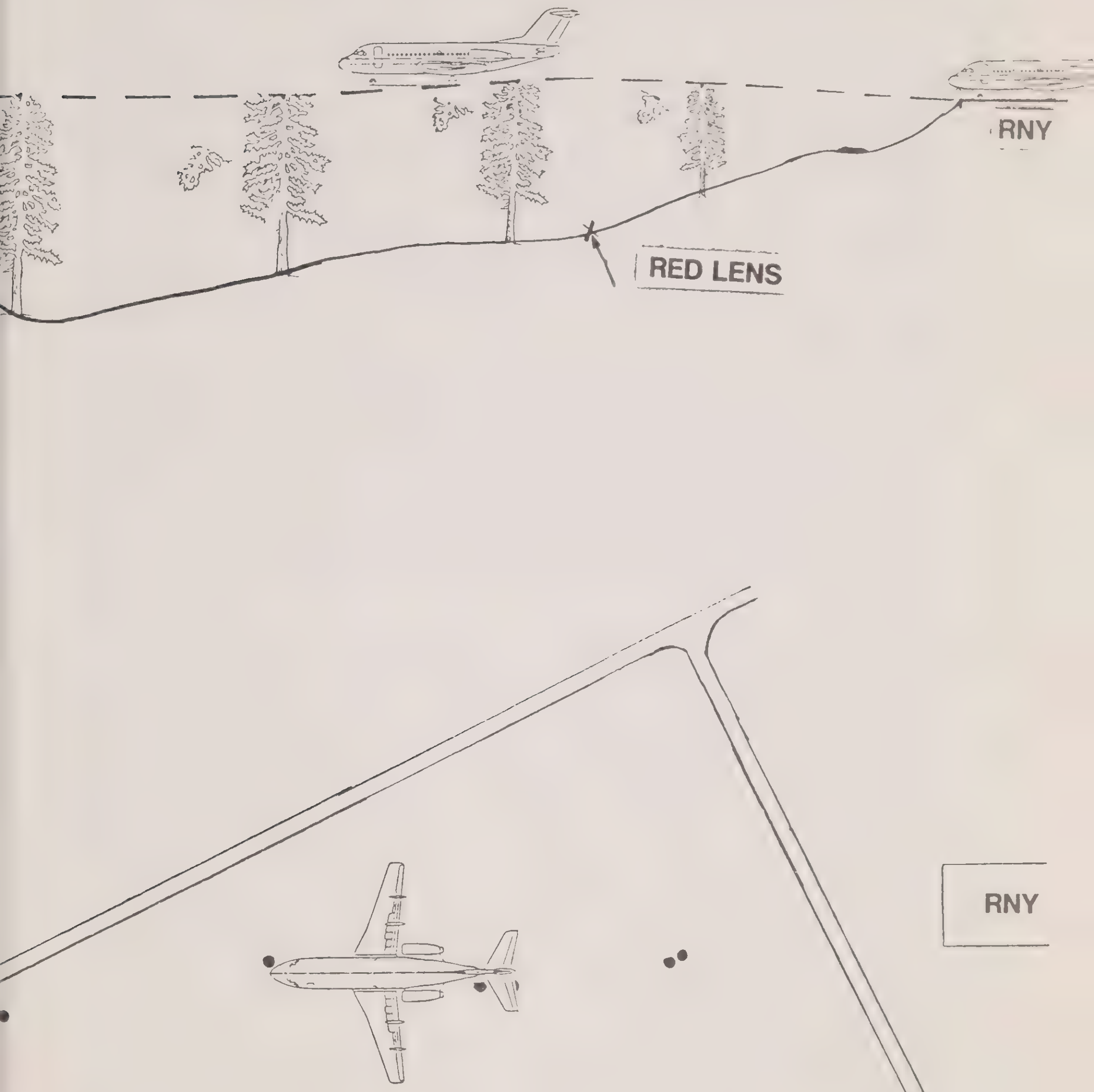
A. ... It was not as it was before. It was not just snow on the rest of the wing, it seemed like it had crystallized on what I could see of the rest.

(Transcript, vol. 16, pp. 234, 236)

Figure 6-1 Aircraft Flight Plan Profile



Source: Exhibit 484



AIR ONTARIO FOKKER F-28, C-FONF
DRYDEN MUNICIPAL AIRPORT
DRYDEN, ONTARIO
CASB ENGINEERING
PRELIMINARY PLOTS

●●● TREE STRIKES

AIRCRAFT AND TREES NTS

The Takeoff – Eyewitness Observations

The destruction by fire of the flight data recorder and the cockpit voice recorder resulted in heavy reliance being placed upon eyewitness observations of the takeoff. Many persons were interviewed, and evidence was adduced from ten witnesses on the ground who observed all or a portion of the takeoff roll and the takeoff itself. These witnesses were all asked to describe their observations and to note on a sketch of the runway where they recalled specific occurrences, such as the point of rotation of the aircraft and the point of liftoff, to have taken place. As well, a number of passengers on board flight 1363 made observations concerning the takeoff.

All the witness observations were carefully reviewed by the Commission counsel and investigators, and subsequently by experts working with CASB and its successor the Transportation Safety Board of Canada (TSB). The observed locations on the runway of specific occurrences were plotted onto a scale drawing of runway 29 and then converted into distances along the runway, thereby providing a reconstruction of the takeoff roll, rotation, and liftoff of flight 1363 (see figure 6-1). Further, in support of the investigation, Mr Michael Poole of the TSB laboratory analysed the eyewitness testimony and provided the Commission with a computer-generated video flight-path reconstruction. Mr Poole's flight-path reconstruction report and the computer video reconstruction were entered as exhibits and were considered by me as evidence.

Mr Roscoe Hodgins, an experienced pilot, had observed the F-28 aircraft take off some 12 to 15 times in Dryden. On March 10, from a location at the Ministry of Natural Resources building adjacent to the button of runway 29, he heard the F-28 engines power up and saw the aircraft accelerate. It was his testimony that the acceleration of the F-28 was not as rapid as he had observed on the previous occasions. Mr Hodgins did not see the nose of the F-28 lift but stated that he saw the tail go down, at approximately the 3400-foot mark of the runway. He did not see the F-28 lift off.

Mr Stanley Kruger of the Dryden airport crash, fire-fighting, and rescue (CFR) service was in his fire truck parked on taxiway Charlie adjacent to the wind-sock when he observed the takeoff roll of flight 1363. He testified that he saw the aircraft as it accelerated from the button of runway 29 up to a point just east of taxiway Alpha. At that point, approximately the 3100-foot mark of the runway, the F-28 had not rotated.

Mr Craig Brown, a commercial pilot with Terraquest Ltd, with approximately 1250 hours of flying experience, was on the eastern side of the main ramp area when he observed the F-28. He first saw the F-28 when it was at approximately the 2300-foot mark of runway 29. He saw

the nose of the aircraft lift just west of taxiway Alpha. Mr Brown testified that the main wheels of the F-28 stayed on the ground for a considerable time thereafter until the aircraft was observed to leave the runway at approximately the 4900-foot mark.

Mr Allan Haw, who was working as a mechanic at the Dryden airport on March 10, testified that he had previously observed F-28 aircraft land and take off at least 100 times. He first observed flight 1363 when he was working outside a maintenance equipment shed located east of the terminal and south of the runway. He testified that, at approximately the 2700-foot mark of the runway, the F-28 was going considerably slower than it should have been at that point on the runway. Mr Haw expected the F-28 to abort its takeoff, and he therefore continued to watch what was transpiring closely. At approximately the 5700-foot mark of the runway, he observed the F-28 in the air: "I could see sky between the underpart of the airplane and the tree tops" (Transcript, vol. 24, p. 140). He described the takeoff as being very shallow and slightly nose up.

Mr Gary Rivard, also of the airport CFR services, was on the eastern side of the ramp area in front of the terminal when he observed the F-28 on its takeoff roll. He testified that, at approximately the 3200-foot mark of the runway, just east of taxiway Alpha, all wheels of the aircraft were on the ground.

Mr James Esh was working as a ground handler for Dryden Air Services and, as of March 10, had approximately 140 hours of flying experience as a pilot. He was walking west on the tarmac just to the west of the terminal building when he heard the F-28 throttling up. He glanced over and first observed the F-28 at about the 3600-foot mark of the runway with all wheels on the ground. Mr Esh then continued to observe the takeoff roll:

> A. ... from that point, I watched the rest of his ground run there. And he went to approximately the 11 numbers[1] on the west side of the runway before he rotated, and it looked like he really reefed on the controls, just, you know, hauled back.
>
> He had an extremely high angle of attack, and the right wing dropped just a bit, and it looked like he corrected, and it also looked like he overcorrected just – just a bit. And the left wing dropped just a bit, and he corrected that.

[1] The term "11 numbers" refers to the markings on the west end of the runway approximately 350 feet from the end.

> And it just looked like he was mushing along there in a high angle of attack, not gaining any altitude, and he disappeared behind the trees in the snow.
>
> (Transcript, vol. 24, pp. 203–204)

Mr Martin Gibbs was the co-pilot of a NorOntair Twin Otter, which was the first plane to take off after flight 1363 had crashed on March 10, 1989. He had approximately 1760 hours of flying experience. While the F-28 was on its takeoff roll, he was in the airport manager's office in the terminal building looking out towards the runway; he observed the F-28 to have a "positive attitude" with the nose wheel apparently off the ground at approximately the 3800-foot mark (Transcript, vol. 23, p. 23). He testified that the aircraft was airborne at taxiway Alpha, with all wheels off the runway. Once the aircraft was past taxiway Alpha, the right wing appeared to dip, the right main gear appeared to contact the runway, and the F-28 appeared to level out.

Mr Jerry Fillier, a ground handler with Dryden Flight Centre, was standing on the ramp outside the terminal building when he first observed the F-28. He testified that, just east of taxiway Alpha, the F-28 had all wheels on the ground. He next observed it just west of taxiway Alpha when the nose wheel was off the ground and the aircraft was rotating.

Mr Christopher Pike, a maintenance employee at the airport, was also in the airport manager's office when the F-28 was taking off. He first observed the F-28 at the intersection of the runway and taxiway Alpha. He stated that it had all wheels on the ground and appeared to be going slower than it should have been at that point on the runway. At approximately the 4400-foot mark Mr Pike observed the F-28 take a "skip and hop" with the left wing coming up and the right wing dropping. Then he observed the F-28 to lift off at the 5700-foot mark of the runway. He was very certain of this observation since his line of sight of the aircraft was lined up with the first set of VASIS (visual approach slope-indicator system) lights. Mr Pike testified that the aircraft did not seem to want to fly but rather "kind of waddled through the air" (Transcript, vol. 28, p. 36).

Mr Norbert Altmann, captain of the NorOntair Twin Otter and with approximately 5000 hours' flying experience, was in the weather office located at the northwest corner of the terminal building on March 10 while the F-28 was on its takeoff roll. He observed it at approximately the 5000-foot mark of the 6000-foot runway. He noted that it had a nose-high attitude and that it was low for being so far down the runway.

Observations by passengers on board flight 1363 were of assistance in determining the movements of the aircraft during the takeoff roll and,

by and large, were consistent with the observations made by people on the ground.

Captain Berezuk testified that approximately 500 to 1000 feet past taxiway Alpha (at approximately the 4000-foot mark of the runway) the aircraft attempted to rotate and began to shudder; the nose of the aircraft was then lowered to one-half of the initial rotation angle (from an estimated 10° to 4° or 5°). Captain Berezuk testified that there was a second rotation but was unclear as to where it occurred.

Flight attendant Hartwick also recalled the aircraft initially attempting to rotate, not succeeding, and then rotating a second time. She was not able to specify where these rotations occurred, but stated that on the first attempt it felt like the aircraft bounced, came back down onto the runway, continued down the runway, bounced again, and stayed in the air. At the time of the second bounce, the aircraft jerked to the left with the left wing coming down.

Passenger Ronald Mandich, a professional engineer with aviation experience in the management of flight test programs and vibration testing for Hughes Aircraft Corporation, described the takeoff roll. Mr Mandich testified that, as the aircraft gained speed during the takeoff roll and the nose pulled up, "it didn't appear to me that the plane wanted to leave the runway as easy or as quickly as it had on the previous flights" (Transcript, vol. 17, p. 357). Mr Mandich also recalled that the aircraft left the runway for approximately two seconds and came back down onto the runway. Then there was an increase in the pitch of the engines and the aircraft left the runway. He estimated that the aircraft, as it flew over the end of the runway, was 15 feet off the ground.

Runway Conditions before and after Takeoff

A number of witnesses testified as to the condition of the runway immediately before and after takeoff. Mr McGogy, the Cessna 150 pilot, described the condition of the eastern end of the runway at about 12:06:30, the time of his landing:

> A. The runway where I landed, there was approximately a quarter inch of slush on the centre of the runway and onto the north side ... had accumulated a bit more. I would say it would be 3/8 to half an inch range of slush.
>
> (Transcript, vol. 22, p. 54)

He also testified about the condition of taxiway Alpha:

> A. Taxiway Alpha, my recollection was exactly the same as the runway was. It was approximately a quarter inch of wet slush on the taxiway.
>
> (Transcript, vol. 22, p. 59)

It is important to note that it was continuing to snow heavily and with increasing intensity after Mr McGogy left the runway in his Cessna 150 and that the slush accumulation on the eastern portion of the runway would have continued to increase during the entire period up to and including the time of the F-28 takeoff roll.

Captain Murray Haines, a passenger on flight 1363 and an experienced Air Canada pilot, described the runway as being covered in slush, with the black of the tarmac visible through it in the centre and with the slush accumulation being more "yellowish" along the edges of the runway.

After the takeoff, personnel at the airport quickly learned that the F-28 appeared to have crashed. Gary Rivard in Red 2 noticed the F-28 on its takeoff roll, almost at taxiway Alpha, just after he finished hosing down the fuel spill in front of the terminal. He was backing up Red 2 when an employee at the airport, James Esh, ran towards him waving his arms while slipping and sliding on the slush-covered surface. Mr Rivard testified that Mr Esh was hollering: "the plane went down, the plane went down, get going ... I looked behind me and I could see all this grey, white smoke in the air" (Transcript, vol. 28, p. 219). Mr Rivard then immediately drove down taxiway Alpha onto runway 29 and proceeded to its western end. He described the condition of the runway to the west of taxiway Alpha:

> A. ... the portion of the runway that I ran on going and coming was a hundred percent bare and wet.
>
> And I made my turn at the end with no problem and that is – when I did that, I noticed Ernie Parry was right behind me.
>
> (Transcript, vol. 28, p. 220)

Mr Rivard further testified that he saw no tracks after he turned his vehicle around at the west end of the runway and doubled back towards the maintenance road.

Chief Ernest Parry had observed Red 2 proceeding at a high rate of speed from the ramp in front of the terminal area up taxiway Alpha. He immediately followed, staying 50 to 75 feet behind it and to the left of the centre line of the runway. He too described that portion of the runway as bare and wet going west and testified that a "very light spray" was coming from the wheels of Red 2 (Transcript, vol. 6, p. 229).

In cross-examination, Chief Parry was asked whether he saw any tracks on the runway after turning around at the west end:

Q. And when Red 2 and yourself turned around and proceeded back, in an eastbound direction, did you see ribbons of tracks?
A. No, sir, I didn't see any trace of any tracks at all. It was just wet pavement.
Q. Not even your own tracks?
A. Not even our own tracks.

(Transcript, vol. 7, p. 16)

Mr Kruger also proceeded onto the active runway in Red 1 moments after the F-28 had taken off. His observations of the runway condition to the west of taxiway Alpha support the observations of Chief Parry and Gary Rivard:

A. Trying to look back and visualize it, I can only describe it as black and wet.

(Transcript, vol. 26, p. 110)

Observations Shortly after the F-28 Takeoff

Mr Norbert Altmann, the NorOntair captain, testified that at approximately 12:30, only 20 minutes after the takeoff of flight 1363, he observed the ramp area in front of the terminal to be clear, black, and covered with wet slush which was one-half inch deep. Mr Altmann's Twin Otter departed Dryden at 12:50 p.m. bound for Red Lake, with Martin Gibbs as the co-pilot. The Altmann/Gibbs aircraft was the first aircraft to taxi to the east end of the runway after the departure of Air Ontario 1363.

First Officer Gibbs described the ramp and easterly portion of the runway, that is, between taxiway Alpha and the button of runway 29, as then having "about a half inch of slush on them." He testified that he was able to see the tracks created in the slush by the F-28 when it backtracked to the threshold of runway 29:

A. ... About halfway down on the backtrack on runway 29, I noticed the F-28 tracks from his backtracking. At that point, I decided to take note of them to see how far down the runway they went, and they went right to the threshold of runway 29.
Q. Now, how thick do you estimate the slush to be?
A. Still, it was about a half inch, a quarter to a half inch of slush.
Q. And was it white or could you see the tarmac or the runway?
A. It was – it was melting. You could see the darkness of the tarmac through it. It was not white.

(Transcript, vol. 23, pp. 30–31)

In cross-examination, Mr Gibbs reiterated as follows:

Q. You indicated that you saw what you thought were the tracks of the F-28 on 29 about halfway down 29.
Can you tell me if those tracks were continuous to what you described as the threshold of 29 or were they intermittent ...
A. They were – from the point that I first observed them, they were continuous, and I believe it was the taxi portion of his departure there. I noticed them right to the threshold where they turned around. Once we straightened out, lined up for takeoff, could see his tracks and our tracks at the same time.
Q. And were these tracks straight or was there any differential to them?
A. As I recall, they were straight.
Q. Were there three tracks or two?
A. I recall three tracks.

(Transcript, vol. 23, pp. 42–43)

Captain Altmann, testifying as to the condition of the runway at this time, corroborated First Officer Gibbs's evidence and stated that there was one-half inch of slush on the runway between taxiway Alpha and the threshold of runway 29:

A. Taxiing out, we back-taxied for departure off of runway 29, which would be going westbound. On the taxi out, I taxied down the middle of the runway. I was looking for foreign objects that might have come off the jet, pieces of shrapnel, whatever, you know, the – having realized that the airplane had crashed, there might be pieces of metal and shrapnel laying on the runway, and I was looking for that.
Q. Did you observe any contamination on the runway, slush or snow?
A. No snow. I would say a thin layer of slush, half an inch thick. That's not a problem for the Twin Otter. I didn't notice the tracks of the other aircraft, the F-28. My co-pilot did notice that. However, my main concern was looking for debris on the runway so that I wouldn't run over it.

(Transcript, vol. 22, pp. 200–201)

The evidence of various witnesses clearly establishes that at the time of the takeoff of flight 1363 there was a buildup of slush, approximately one-half inch in depth, on the eastern half of runway 29 up to the vicinity of taxiway Alpha, and that the western end of the runway was bare of slush but wet.

Findings

- A heavy snow squall covered the entire eastern half of the Dryden airport, extending from taxiway Alpha eastward, between the time flight 1363 departed the terminal area and its takeoff on March 10, 1989.

- The snowfall increased in intensity and continued to fall heavily during the entire period from the time that the F-28 entered the runway and taxied eastward to the threshold of runway 29, at approximately 12:07:00 p.m., until after its takeoff, which commenced at approximately 12:09:40 p.m.

- There was an accumulation of at least one-half inch of wet, layered snow on the wings of the F-28 as it began its takeoff roll.

- The snow on the forward part of the wings of the F-28 aircraft, the area most critical to aircraft lift, froze and crystallized to form dull, greyish opaque ice, of a rough sculptured-carpet texture, during the takeoff roll, while some of the snow on the back part of the wings was blown off.

- The usual point of rotation of the F-28 aircraft during routine takeoffs, observed on other occasions, from runway 29, was at a location prior to taxiway Alpha, some 3100 feet to the west of the threshold of runway 29.

- After a longer than normal takeoff roll, the F-28 aircraft, C-FONF, was rotated near taxiway Alpha, at approximately the 3500 foot mark. The aircraft lifted off slightly, began to shudder, and then settled back down onto the runway.

- The takeoff roll then continued and the aircraft was rotated a second time, finally lifting off at approximately the 5700 mark of the 6000 foot runway. It flew over the end of the runway approximately 15 feet above the ground. It thereafter failed to gain altitude and mushed through the air in a nose-high attitude, before commencing to strike trees.

- There was an accumulation of between one-quarter inch and one-half inch of wet slush on the runway as the F-28 aircraft entered the runway at approximately 12:07:00 p.m. and commenced back-tracking to the button of runway 29.

- At the time of commencement of the takeoff roll by C-FONF, 12:09:40 p.m., there was a runway surface accumulation of slush between one-quarter and one-half inch in depth extending from the threshold of runway 29 to taxiway Alpha. The remainder of the runway, being in the airport area to the west of taxiway Alpha, and not affected by the snow squall, was bare of slush but wet.

7 THE CRASH AND THE RESPONSE

The Crash

Air Ontario flight 1363, after a longer than normal takeoff run, rotated and struggled into the air about 4000 feet down the runway. It settled back onto the runway and continued its takeoff run before lifting a few feet into the air virtually at the end of the runway. The aircraft was unable to gain any altitude. It began contacting trees 127 metres from the runway end and then barely cleared a treed rocky bluff some 700 metres west of the runway, before going down into a wooded area, coming to rest 962 metres from the end of the runway.

Standing on the tarmac outside the terminal building, Mr James Esh, who described the events in his testimony to the Commission, continued to watch after the aircraft left the ground:

> Q. Did the aircraft climb at all?
> A. No, it didn't.
> Q. And what happened next?
> A. Then I could remember hearing the engines still screaming away, and then there was a – about half a second of – or a second of just silence. Then there was a big orange or red fireball with a mushroom cloud of black smoke.
>
> (Transcript, vol. 24, p. 204)

Mr Craig Brown of Terraquest Ltd saw the aircraft disappear behind trees:

> A. After one- or two-second delay, there was smoke and a fireball.

He described the smoke as "very black and with orange glowing flames in it" (Transcript, vol. 5, p. 234).

After contacting the first treetop, the aircraft continued another half kilometre, striking more treetops and leaving a trail of wreckage before hitting a substantial number of trees while clearing the top of a wooded knoll. Fire broke out on the left side of the aircraft as it descended beyond the knoll, and its left side struck the ground first. It came to a stop against a stand of trees, breaking into three pieces (see figure 6-1 in the preceding chapter, Takeoff and Crash of Flight 1363). The tail section faced forward, the main section of the fuselage turned to the left of the

tail section, and the cockpit section rotated further to the left of the fuselage, so that the main wreckage formed an approximate u-shape.

The fire followed the aircraft path until the aircraft finally came to rest. After the crash, fire was confined to the crash site and to the trees along and beside the trail of wreckage. Infrared photography reveals the charring of trees that occurred during the crash fire. The fire gutted the fuselage from the interior of the cockpit back to the rear pressure bulkhead, but left part of the right side of the fuselage in place, with the exterior paint scheme charred but recognizable (see colour plates).

Crash Fire Rescue Response at the Terminal

The primary objective of crash, fire-fighting, and rescue (CFR) services is to save lives in the event of an aircraft accident or an aircraft or airport fire, and the emphasis is on CFR personnel providing a fire-free escape route for passengers and crew. A secondary objective is to preserve property by containing, or extinguishing where practical, any fire resulting from an aircraft accident or incident.

As of March 10, 1989, the airport at Dryden, Ontario, was equipped and staffed according to Transport Canada's requirements for CFR services. The complement of CFR unit staff at the Dryden airport was as follows: Ernest Parry, chief of the unit, with six years' service; crew chiefs Stanley Kruger and Bernard Richter and fire-fighter Gary Galvin, each with six years' experience; and two other fire-fighters, Kenneth Peterson and Gary Rivard, each with one year's service. Three CFR vehicles were involved in the events of that day: Red 1, a rapid intervention vehicle, driven by Mr Kruger; Red 2, a tanker truck, driven by Mr Rivard; and Red 3, a utility van, driven by Chief Parry.

Red 1 had returned to the fire hall, and Mr Rivard had just finished washing down the fuel spill by the terminal building when he was told that flight 1363 had probably gone down. He immediately drove Red 2 to the end of the runway. Chief Parry noticed Red 2 proceeding at speed towards the active runway, realized that something was wrong, and drove out onto the runway behind Red 2.

Both Red 2 and Red 3 drove west at a high rate of speed on the active runway. When it became obvious that they could not reach the location of the smoke from the runway, both vehicles turned around and proceeded back towards the terminal area. Chief Parry testified that while he was still on the runway he was fairly certain that the aircraft had crashed. He left the active runway in Red 3 at taxiway Alpha. Red 2, turning at high speed, skidded off a service road, got stuck in a snow bank, and had to be pulled out by airport employee Christopher Pike using a front-end loader. Mr Rivard then topped up Red 2 with water to replace what had been used washing down the fuel spill.

Between 12:09:29, when Air Ontario flight 1363 advised the Kenora Flight Service Station that it was about to roll, and 12:12:47, there were a number of radio communications questioning the whereabouts of the flight and involving Chief Parry in Red 3, Kenora FSS, and air traffic control out of Winnipeg. At 12:12:47 Chief Parry advised that the aircraft might have gone down west of the airport, since smoke could be seen in the distance, and further advised that he was proceeding in that direction. At 12:14:00, Chief Parry advised the Town of Dryden police dispatch that he suspected the F-28 jet had gone down approximately three or four miles west of the runway and requested that the mutual aid and emergency plan be activated.

At the Air Ontario Counter

After the crash of flight 1363, Mr Vaughan Cochrane, the Dryden Flight Centre general manager, went to the Air Ontario counter and called London SOC. He also told Ms Jill Brannan to "lock everything up, we just had a crash" (Transcript, vol. 20, p. 121). She testified that she gathered all papers relating to the crash, such as flight manifests and passenger lists, and locked them in a drawer at the counter. Later that afternoon, the contents of the drawer were given to Mr Cochrane, who took them to the Dryden Flight Centre office. Ms Linda Harder, the senior Dryden Flight Centre passenger agent, testified that when she arrived at the airport at about 2:00 p.m. she sealed the documents in an envelope:

> Q. And the documents which we were talking about, Mrs Harder, generally what did they constitute?
>
> A. The passenger manifest, the lifted-ticket coupons, the messages that had been received pertaining to the flight from previous downline stations.
>
> (Transcript, vol. 25, p. 116)

Despite the best efforts of Commission staff, these documents were never located.

At the Scene

Chief Parry in Red 3, joined by Stanley Kruger in Red 1, left the airport property via the airport's public access road and thereafter travelled westward by public highways to McArthur Road and Middle Marker Road. Chief Parry positioned Red 3 at the intersection of the two roads, unlocked the gate leading into Middle Marker Road, and waved Red 1 down that road. It was estimated that Chief Parry arrived at the

intersection at approximately 12:18 p.m. He established a command post there.

The aircraft had crashed in Wainwright Township, an area under the overall command of the Ontario Provincial Police. The fire-fighting responsibility for this location was held by the Unorganized Territories of Ontario (UT of O) Fire Department under the direction of Chief Roger Nordlund. Chief Parry, however, was the first responsible fire-fighting official to arrive near the crash site. He testified that, when he established the command post, he in fact had "no official jurisdiction" at the site, but was simply responding to the situation.

The first OPP officer to arrive at the site was Sergeant Douglas Davis, who testified that he arrived at the intersection at approximately 12:30 and assumed control of site access, egress, and security.

Two civilians, Mr Craig Brown and Mr Brett Morry, were the first persons to actually reach the crashed aircraft, making a path through the deep snow. Mr Brown and Mr Morry had left the terminal immediately on seeing the orange fireball and had driven towards Middle Marker Road. Finding the gate closed, they climbed over the fence and hurried down the road until they reached a point that seemed to be near the aircraft. They then made a trail through the waist-deep snow towards the smoke and sounds of fire. Arriving at the aircraft, they saw a number of survivors, some in quite good condition and others seriously injured.

Crew chief Kruger drove Red 1 nearly to the end of Middle Marker Road and parked. He then followed on foot the path made by Mr Brown and Mr Morry, carrying with him a portable radio and a first-aid kit weighing 11.5 kilograms. He initially estimated the distance from the road to the aircraft at 150 yards. As he came close to the crash site he encountered about 20 survivors, whom he directed to walk out to the road. These 20 to 25 survivors reached Middle Marker Road at approximately 12:32 p.m., just after Sergeant Davis arrived at the intersection. Sergeant Davis testified that he first saw them after speaking to Chief Parry, and that some of them appeared burned and had other injuries.

By the time Mr Kruger arrived at the aircraft, all but one of the surviving passengers had gotten out of the crashed aircraft. Mr Uwe Teubert and Mr Michael Kliewer, who had not yet been discovered, were trapped outside on the left side of the aircraft until approximately 1:10 p.m., when they were freed from the wreckage and attended to by rescuers including Dr Gregory Martin and Dr Alan Hamilton, both of Dryden. They were carried from the crash site and transported by ambulance to the Dryden hospital at 1:45 p.m. Mr Kliewer subsequently died.

During the hour and a half from 12:15 to 1:45, all other surviving passengers either made their own way to Middle Marker Road or were assisted by various persons from the Dryden airport CFR unit, the UT of O fire-fighting unit, the Town of Dryden fire-fighting unit, officers from the OPP, civilians, and by medical personnel from the Dryden Municipal Hospital.

Handlines from UT of O fire vehicles positioned on Middle Marker Road were not brought into the crash site until between 1:50 and 2:00 p.m. At approximately 2:00 p.m., one hour and 50 minutes after the crash occurred, foam was first applied to the fire, using the handlines. Mr Raymond Godfrey, a volunteer member of the UT of O Fire Department, was one of those who took the hose in from UT of O firetruck No. 4. He testified that about 10 or 12 people were involved in taking the hose into the crash site and that the operation took 5 or 10 minutes.

Crew and Passenger Injuries

Twenty-one passengers and three crew members died as a result of the crash. Forty-four passengers and one crew member survived. Most of the passengers who died were seated in the left and front portion of the aircraft. The majority of the bodies recovered at the crash site were badly burned in the subsequent aircraft fire, which made it difficult to determine the various injuries and specific causes of death. All the fatalities were investigated and their body shift, major injuries, suspected cause of death, and gross estimate of survival time were documented. Twenty-two people died at the site and two died in hospital – Mr Kliewer approximately three hours after the crash, and Mrs Nancy Ayer approximately 11 hours after the crash. Of the 45 people who survived the crash, 18 required hospitalization. Appendix H at the end of this Report is a summary of the information on the fatalities and survivor injuries.

The Afternoon of March 10

Two matters of significance occurred in relation to the Dryden airport on the afternoon of March 10. The evidence is that Red 1, 2, and 3, being all of the Dryden CFR fire-fighting equipment, left the airport to attend at the crash site. The last vehicle to depart the airport was Red 2, which left at approximately 12:30 p.m. It was not until 3:46 p.m. that a notice to airmen (NOTAM) was issued by the Kenora FSS to advise that CFR coverage was not available at the Dryden airport. At 4:30 p.m., after a Town of Dryden firetruck arrived at the airport CFR fire hall, a further

NOTAM was issued by Kenora FSS, advising that CFR coverage was again available at Dryden. From approximately 12:30 p.m. until 4:30 p.m., there was no CFR coverage available at the Dryden airport, and from 12:30 p.m. to 3:46 p.m. there was no notification of this lack of coverage. There were landings and takeoffs at Dryden airport during these hours, as was shown by the evidence of several witnesses and by notations made in the daily air traffic record for that day. Mr Peter Louttit, the airport general manager, testified that the failure to issue the NOTAM in a timely manner was a technical error that should not have occurred.

At approximately 2:00 p.m. Mr Louttit asked Mr Arthur Bourre to look for debris on the runway. Mr Bourre had worked for the Town of Dryden for approximately ten years, nine years as a weather observer and most recently as an equipment operator. He drove out the maintenance road east of taxiway Alpha and onto the active runway. He travelled along the north side of the centre line to the button of runway 29, turned around, and drove back on the south side of the centre line to the button of runway 11. He testified that the runway was covered with slush, which was deeper and whiter towards the east. He estimated that the slush was from three-quarters to one and one-half inches deep. His evidence leaves no doubt that the snowfall over the eastern half of runway 29/11 did not abate until some time after the takeoff of flight 1363.

As he proceeded to the button of runway 11, the slush diminished, and he estimated that the slush at that end was at least three-quarters of an inch deep. Although Mr Bourre did not perform a James Brake Index test, it was his assessment that "it [the runway] was very slippery, and, in my estimation, the braking action was nil" (Transcript, vol. 28, p. 133). The slippery condition of the runway was reported to Mr Louttit at approximately 2:30 p.m. He took no immediate action to have the runway cleaned but simply told Mr Bourre "to stand by" (Transcript, vol. 28, p. 134).

Mr Bourre observed pieces of ice sticking out of the slush on the runway between the maintenance access road and taxiway Alpha. Although he was not certain of the origin of this ice, it was his opinion that it had come from the CFR vehicles that had driven on the runway. Evidence as to the origin of the ice was inconclusive.

Removal of the Bodies

Sergeant Paul Miller of the OPP Technical Identification Services Unit in Kenora, Ontario, was assigned as the identification officer responsible for the Dryden crash. He arrived at the Dryden OPP detachment at approximately 6:00 p.m. on March 10, and reported to the crash site at approximately 7:30 p.m. After touring the crash scene, he formulated a plan for recording and examining the site and removing the bodies from the aircraft wreckage.

Before Sergeant Miller arrived, another OPP officer had marked the locations of 21 individual bodies in the aircraft, with another subsequently identified for a total of 22. On Saturday, March 11, Sergeant Miller initially viewed the site by air and prepared a video of his observations. He and other OPP officers arrived at the crash site at approximately 11:00 a.m. No remains were removed from the aircraft until after the Canadian Aviation Safety Board (CASB) investigators attended at the site and, in conjunction with the police investigation on March 11, photographed and documented the position of the bodies. Measurements of the wreckage were taken, and the locations of bodies were identified and marked precisely. Removal of the bodies commenced in the early afternoon. The bodies of 11 people had been removed by the time hazardous working conditions caused by darkness stopped the work on Saturday. The remaining bodies were removed from the aircraft wreckage on Sunday, March 12. All the bodies were taken to a temporary morgue set up at the Dryden arena under the security of the OPP. Because of poor weather conditions, the remains were transferred from Dryden to Thunder Bay by ground transport rather than by air. They were then transported from Thunder Bay to Toronto via an Air Ontario Convair aircraft. Sergeant Miller accompanied the remains from Dryden to Thunder Bay and Toronto.

Upon arrival at Toronto the bodies were transported to the Forensic Pathology Branch of the Ministry of the Solicitor General on Grenville Street, arriving at approximately 8:15 p.m. on March 13. It should be noted that, in addition to the bodies removed from the aircraft, the body of Michael Kliewer, who died at the Dryden hospital, was also transported from Dryden to Toronto.

Post-mortem examinations were performed in Toronto between March 14 and March 22, 1989. Mrs Nancy Ayer, who survived the crash, subsequently died at Winnipeg Memorial Hospital and a post-mortem was performed in Winnipeg, Manitoba, on the morning of March 14, 1989.

Finding

- The F-28 aircraft failed to gain altitude after takeoff, maintaining a flat, nose-high flight path until it began impacting trees 127 metres from the runway end. It barely cleared a treed rocky bluff 700 metres west of the runway before going down into a wooded area where it broke up into three sections, coming to rest 962 metres from the end of the runway.

8 DRYDEN AREA RESPONSE

Emergency Services

At 12:14 p.m. on March 10, 1989, while en route to the crash scene, CFR Fire Chief Ernest Parry made the following transmission to the Town of Dryden police dispatch:

> This is Airport Red 3. We suspect we have an F-28 jet down approximately 3 or 4 miles west of the runway. Please activate the mutual aid and emergency plan.
>
> (Dryden Dispatch Fire Tape)

In so doing he initiated the mobilization of all the emergency assistance available in the area. This one radio call resulted in the notification of the emergency to three fire departments, the Dryden Police Department, the Dryden hospital, the Dryden Ambulance Service, and the Ontario Provincial Police (OPP).

Mutual Aid

There are three fire departments in the Dryden area, the Dryden airport crash, fire-fighting, and rescue (CFR) unit, the Town of Dryden Fire Department, and the Unorganized Territories of Ontario (UT of O) Fire Department. On March 10, 1989, the CFR unit at the Dryden airport was the only full-time, professional fire-fighting team in the area. The Town of Dryden's Fire Department is a volunteer unit and only the chief is a full-time fire-fighter. The UT of O Fire Department, which responds to fires in the townships of Aubrey, Van Horne, Wainwright, Britton, Eton, Rugby, and part of Zealand, is an entirely volunteer force. The crash site was in Wainwright Township, west of the airport and north of the town limits of Dryden, and therefore within the fire response area of the UT of O Fire Department.

The UT of O Fire Department was established in 1981 with some equipment and funds provided by the Ontario Ministry of Northern Affairs and the Office of the Ontario Fire Marshall in addition to local funds. At the present time, each landowner in the area pays a small levy to support the operation of the department.

The department has two fire halls and a complement of 23 men. Fire hall number 1, located on Highway 7 in Wainwright Township, contains a rapid attack truck, a tanker truck that carries 1000 gallons of water and a port-a-pond, and an equipment van. The port-a-pond consists of a collapsible steel framework and a canvas liner. When set up, it forms a pond into which the tanker, or other water-carrying vehicle, can quickly dump water. The attack truck can draw water from this pond and pump it onto the fire while the tanker returns to a supply point to refill. Fire hall number 2, on Highway 502 south of Dryden, contains another rapid attack truck and a pumper that carries 750 gallons of water.

At the time of the crash, agreements for mutual aid were in force between the Town of Dryden and the airport CFR unit, and between the Town of Dryden and the UT of O Fire Department. As part of the mutual aid agreement, the Town of Dryden provides dispatch services for the UT of O Fire Department. All calls from the UT of O area are received by the Dryden police dispatch, which then sounds the alarm via pagers carried by all the UT of O volunteer fire-fighters.

These three fire-fighting units, all of which responded to the crash site, were also members of the Kenora District Mutual Fire Aid System. The document describing this system outlines its purpose as follows:

> The role of the fire service ... is to develop plans to improve the effectiveness of fire protection facilities within the District of Kenora, to cope with large scale fires and emergencies which are beyond the ability of a single fire department or fire protection team to control.
> (Exhibit 39, p. 1)

The Emergency Plan

In his radio call on the way to the crash site, Chief Parry not only called for mutual aid to fight the fire, but also asked that the Town of Dryden Peacetime Emergency Plan be activated.

Dryden had had a rudimentary emergency plan for a number of years. In 1979 the town council decided that, because both the Trans-Canada Highway and the main line of the CPR run through town and many chemicals are used in the large pulp and paper mill that is the town's major employer, the plan should be formally reviewed, updated, and approved by the council.

Dryden Fire Chief Louis Maltais undertook this task and the Peacetime Emergency Plan was adopted by council in January 1980. The aim of the plan is as follows:

> To lay down a plan of action for the efficient employment of all services required in order that the following be assured:

(a) The earliest possible response to an emergency call by all services that may be required.
(b) An operations control facility be established at the scene and/or elsewhere according to the nature of the emergency.
(c) Crowd control be imposed so that operations are not impeded and that additional casualties are avoided.
(d) The rescue of trapped persons with the minimum of delay and the provision of first aid at the site.
(e) Provisions of controlled evacuation and balanced distribution of casualties to hospitals.
(f) Immediate action taken to eliminate all sources of potential danger in the area of the incident.
(g) The evacuation of buildings considered to be in a hazardous situation.
(h) Provision of such social services as may be required for personnel.
(i) Restoration of normal services.
(j) Factual official information be available at the earliest time to:
    (i) officials involved in the emergency operation
    (ii) the news media to allay anxiety and to reduce the number of onlookers at the scene
    (iii) concerned individuals seeking personal information

(Exhibit 3, p. 2)

The Peacetime Emergency Plan outlines how it can be activated, how the control facility should be established, and who has authority over various areas within the plan. It was tested a number of times through the running of mock disasters, and amended as problems were discovered.

The emergency plan outlines the composition and responsibilities of the emergency operations control group in a section that begins as follows:

All emergency operations will be directed and controlled by a group of officials responsible for providing the essential services needed to minimized [sic] the effects of the emergency.

This is known as the emergency operations control group and is made up of the following:

1. Mayor or alternate
2. Police Chief or alternate
3. Clerk-Administrator or alternate
4. Fire Chief or alternate
5. Town Engineer or alternate
6. Hydro Manager or alternate
7. Telephone Manager or alternate
8. Building Inspector or alternate

9. Medical Office of Health, Northwestern Health Unit or representative
10. Administrator, Social and Family Services or alternate
11. Emergency Planning Officer

(Exhibit 31, pp. 2–3)

Mr Maltais was designated the emergency planning officer under the plan and was responsible for ensuring that the control centre equipment was in place and ready for any emergency.

Town of Dryden Police Dispatch

The Dryden police dispatch is located in the Dryden police station and serves not only the town police, but also the ambulance and fire services of the area, including the UT of O Fire Department. When a call is received, an alert tone is transmitted, followed by an announcement of the type of emergency and its location. This announcement is repeated three times. All the volunteer fire-fighters of Dryden and the UT of O departments carry pagers that can pick up the tone and the announcement.

Dryden Ambulance Service

The Dryden hospital holds a licence from the Ontario Ministry of Health to operate two ambulances that provide service to the Dryden area. The ambulance attendants are hired and paid by the hospital, which is funded by the ministry for these services.

The ambulance service uses both full-time and volunteer ambulance attendants. The full-time attendants require an emergency medical care attendant certificate from a community college. The volunteer attendants must have knowledge of basic first aid and cardiopulmonary resuscitation (CPR).

When necessary, the Dryden police dispatch alerts the ambulance service by telephoning the hospital emergency desk. The on-duty emergency nurse takes the call and then dispatches the ambulance, either by telephone if the attendants are in the hospital or by radio if they are on the road. There is no one assigned full time to answer ambulance calls and dispatch the vehicles.

Preparing for an Emergency

The Dryden Airport

At the time of the air crash on March 10, 1989, the Dryden Municipal Airport Emergency Procedures Manual had not been approved by Transport Canada. The manual had been submitted to Transport Canada for approval, but changes to the manual suggested by the regulator were

disputed by the airport manager at Dryden. These disagreements had still not been resolved by 1989.

On January 29, 1988, Chief Parry of the Dryden airport CFR unit sent a copy of the revised emergency manual for the Dryden airport to H.J. Bell, regional director-general, Airports Authority Group, Transport Canada. The manual was reviewed by Mr Desmond Risto, regional airports disaster planning and protective services officer, who responded to it on February 12, 1988, in a memorandum addressed to the airport manager, Mr Peter Louttit. Mr Risto pointed out a number of concerns regarding the manual, including the lack of specific instructions for Kenora Flight Service Station (FSS) in case of an emergency. He also noted that Kenora should be sent a copy of the existing manual, which could then be updated as revisions took place. Mr Risto testified before me that, to his knowledge, the manual was never sent to Kenora. During an exercise in November 1988, CFR was not called out by Kenora FSS for eight minutes because a new controller was not aware of the responsibility to do so. In spite of this, the unapproved manual had not been sent to the Kenora FSS as of the time of the crash.

In his memorandum of February 12, 1988, Mr Risto had indicated that a number of required items were missing from the draft manual:

> 7) There are eleven (11) sections that the AK identifies that *must* be included in the manual as a minimum. There does not appear to be any thing covering the headings Medical Emergency, Natural Disasters, Hazardous Material Handling or Persons of Authority.
>
> (Exhibit 209, p. 2)

In his testimony, Mr Risto was asked about the missing items referred to in his memorandum:

> Q. ... Were these matters all lacking in the existing Dryden manual?
> A. They were nonexistent.
> Q. All right. And when we talk about persons of authority, what does that mean, sir?
> A. The persons of authority identifies who, for example, would be responsibilities of the airport manager, the responsibilities in authority of the Town of Dryden Fire Department or the Fire Chief of the Unorganized Territory of Ontario, the responsibilities – there – of the head of the Ontario Provincial Police.
>
> (Transcript, vol. 30, p. 79)

At the end of the letter, Mr Risto informed Mr Louttit that a generic manual had been developed for Red Lake that might assist him in

developing a final manual for Dryden. He promised to forward this sample manual to Dryden for their information.

On May 3, 1988, Mr Louttit acknowledged receipt of the approved Red Lake manual and advised Mr Risto as follows:

> While there appear to be advantages to both approaches, we prefer our own format for the time being. We are returning the Red Lake manual to you and shall make the necessary changes in our manual, as noted by Mr Risto, and forward it for approval.
>
> (Exhibit 212)

Throughout the correspondence between Dryden and Transport Canada, there are references to, among other things, matters of nomenclature. Transport Canada continued to request the use of nationally accepted acronyms, while the Dryden airport manager preferred to use local terms. On March 1, 1989, just 10 days before the crash, another revision was forwarded to Transport Canada. Again, Transport Canada noted problems with terminology. It appears as though this preoccupation over nomenclature overshadowed the resolution of the more important problems with the plan, and, on March 10, 1989, there was no approved emergency plan for the Dryden airport. Whatever the disputes, Transport Canada had the authority and the power, through lease and subsidy agreements, to insist that the plan be written in an acceptable manner, including the use of nationally accepted acronyms. As well, there is no logical reason why the Dryden airport management could not have agreed to the request of Transport Canada in view of the fact that it is Transport Canada that sets the standards and assesses the completeness of emergency plans.

Exercises Involving Crash, Fire-fighting, and Rescue

It is the policy of Transport Canada that each airport CFR unit should test the readiness of personnel and equipment to respond to an emergency. Every two years, each airport is expected to run a full-scale exercise involving a simulated aircraft crash with response by off-airport agencies, such as police, ambulance, and local fire departments; this exercise is evaluated by Transport Canada representatives. In the alternate years, a locally evaluated exercise should be run to test individual parts of the response mechanism.

Full-scale exercises were held at Dryden in 1985 and 1988. In both cases, all responding agencies were involved in the planning and execution of the exercise. The 1985 exercise was originally scheduled for December 18, 1984. Unfortunately, the day before the planned exercise, "torrential rainfall fell throughout the whole area" rendering some roads

impassable, and the exercise was postponed. Because of a reluctance on the part of the CFR unit to carry out a training exercise in winter weather conditions, the exercise was rescheduled, finally taking place on November 23, 1985. While one can understand the reluctance to carry out training exercises in winter, the failure to do so ignores the fact that aircraft crashes can and do occur in winter weather conditions.

The November 1985 exercise was code-named Bravo Two and the scenario involved an aircraft that had problems on takeoff, came back down on the runway, and skidded to a stop at the west end of the runway, where it broke up. The exercise was organized by crew chief Stanley Kruger, and the on-site coordinator (OSC) was the senior CFR member on duty, Mr Bernard Richter. The exercise involved all of the major emergency agencies in the area, including the UT of O Fire Department, Dryden Fire Department, Dryden hospital, OPP, Dryden ambulance, the Red Cross, and the Dryden police. Chief Parry was one of the evaluators of the exercise.

Overall, Bravo Two was a beneficial exercise. Certain major problems were identified in the evaluator's report. The OSC moved from place to place and it was difficult for him to be found and identified during the emergency. It was emphasized that the OSC should remain in one place for easy identification and communication. In addition, the response of the OPP was thought to be slow. From the time of the original alarm, 40 minutes elapsed before an OPP officer was observed at the scene. He apparently had initially been sent to the wrong location. The report also noted that no body count, protection of property, photography, or identification work was undertaken or simulated.

In 1986, a local communications exercise was held. While a number of elements were tested, the most important involved the communications equipment and procedures. Significantly, the exercise critique noted that a common radio frequency was needed on which all agencies involved could be contacted. In this exercise, the airport manager was the OSC, and Chief Parry again was an evaluator.

The final report for the 1986 exercise was submitted to Transport Canada on January 14, 1987. In his covering letter to Mr Risto, Chief Parry remarked:

> I see from your "Schedule of Exercises" that we are due for a full-scale exercise in 1987. With the present trend in funding this may not be possible. I'm sure your [sic] are working on the problem as it is not unique to Dryden but affects all airports. However, a policy statement on the status of exercises would be appreciated at this time, so it can be properly dealt with in the funding negotiations.
>
> (Exhibit 229, p. 1)

No documentation was presented to the Inquiry to indicate that any planning whatsoever was done for a full-scale exercise in 1987, as mandated by the Transport Canada schedule. I am convinced that no such exercise was planned for 1987, and only a real incident allowed for any testing of the emergency systems in Dryden that year.

On November 9, 1987, the crew of an Air Ontario HS-748 cargo flight had problems lowering the undercarriage and diverted to Dryden, because of the presence of a CFR unit there, to make a wheels-up landing. This emergency was responded to by the UT of O Fire Department, Dryden ambulance, the OPP, and the airport CFR unit. Just before landing, the crew was able to lower the landing gear and a safe landing was made. This incident was then written up as a "Report on Emergency Exercise" and submitted to Transport Canada to fulfil the full-scale exercise requirement for 1987.[1]

Since Transport Canada did not evaluate the 1987 emergency, another full-scale exercise was scheduled for Dryden in 1988, and, on this occasion, advance planning included all the major agencies in the Dryden area. Again, the scenario involved an aircraft crash on airport property. Code-named Delta Four, the exercise was conducted on November 1, 1988, just four months before the Air Ontario crash of March 10, 1989. Ironically, because of a problem with an oil-pumping mechanism, Chief Parry was unable to fuel or ignite the fire at the practice site. As a result, the exercise did not include any fire suppression activities.

Again, in this exercise, there was a problem with identifying the OSC. He was wearing a vest that identified him as the OSC, but his vehicle carried no such marking. Mr Stanley Kruger, the OSC, spent much of his time moving about to control and coordinate, rather than having responding agencies report to him. The Transport Canada evaluator's report, prepared by Mr Risto, commented on one of the deficiencies noted:

> Having two fire trucks at the scene and as a member was required to take on the duties as OSC and the fact that there was no fire, OSC

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[1] Exhibit 50, Transport Canada AK-13-01-002, Policy, Standards, and Guidelines for the Development of an Airport Disaster/Emergency Plan and the Conduct of Exercises at Transport Canada Airports, states as a Note to section 2.02 (b): "Should a real emergency situation occur at a Transport Canada airport (such as a real crash or an actual highjacking), which necessitates a full response to the airport from all participants included in the airport's emergency plan (i.e., police, hospitals, fire departments, coroner, etc.), the yearly requirement to hold that specific exercise will be considered to have been met."

> should have relocated his vehicle closer to the only access road. This would have given him immediate identification and control.
> (Exhibit 236, p. 2)

Both of the full-scale exercise reports which were put in evidence identified problems with the role of the OSC. It is unfortunate that a fire was not lit in the course of this exercise. If it had been, the problems and responsibilities of the OSC would have been identified in a much more realistic and effective manner. On the day of the crash of flight 1363, Chief Parry positioned himself at the only access road to the crash site to direct and control, as the exercise reports suggested, but, unlike the exercise, there was a fire to fight.

In his report of the 1988 exercise, Mr Risto complimented the UT of O Fire Department for its role in the exercise:

> Good response of "numbers" of personnel. Handlines extended, maintained and manned throughout exercise, which was exceptional.
> (Exhibit 235, p. 2)

In the local debriefing that followed the November 1, 1988, exercise, communications were again identified as being the primary problem. Chief Parry was the acting airport manager at the time of this exercise and therefore responsible for setting up the control centre in the airport terminal building. In this role he called in the various agencies that were required, and coordinated the sending of them to the site upon their arrival at the control centre. Although he was able to communicate with the town dispatcher, he was not able to contact the OSC, Mr Kruger, on the same radio frequency. Some of the verbatim comments from the local debriefing with respect to this exercise are reproduced below:

> Roger Nordlund stated there [sic] biggest problem was there was no one around to direct them to the crash site and organization was lacking.
>
> The hospital had problems responding because of no clear indication of where the incident took place and there was poor communications with the site after the ambulance did arrive there was no indication of how many casualties were involved.
>
> Also there was a problem with the Red Cross registration, this was going to be resolved. There was a problem with the ambulance staff being able to identify the on scene commander with all of the emergency vehicles bunched in and around the scene of the accident.
>
> John Callan spoke regarding communication with the emergency control group and the frustration caused by not being able to keep track of what is going on. He mentioned that the most obvious solution to the problem was a common frequency which would be used by everyone.

> Larry Moore spoke for the OPP and their problems were also communication he was wondering whether one common frequency would be enough and could one operator be able to handle the traffic. The OPP new radio system will not be in place before April 1992.
>
> (Exhibit 236, attachment number 3, p. 2)

This lack of a common frequency was noted by many as the single biggest problem revealed by the exercise and it was a problem that would recur on March 10, 1989.

A review of the tasks performed by the Dryden CFR unit personnel in the three exercises discussed above shows the following:

- During exercise Bravo Two in 1985, Mr Kruger organized the exercise, Chief Parry was an exercise evaluator, and Mr Richter, the senior CFR person on duty, was the OSC.
- During the local communication exercise in 1986, the airport manager was the OSC, and Chief Parry was an evaluator.
- During exercise Delta Four in 1988, Mr Kruger was the OSC and Chief Parry was the acting airport manager.

As can be seen, Chief Parry never acted as the OSC or as the chief of the Dryden CFR unit during any reported exercise between 1985 and the time of the Air Ontario crash. There was no evidence found that showed that any Dryden airport manager or Transport Canada official was concerned about the lack of training for Chief Parry in his primary role, that of the CFR chief, although there is evidence that Transport Canada was concerned with the training, in general, of the CFR unit.

The exercises at Dryden normally involved an aircraft accident scenario, and the primary goal of such aircraft accident responses should be the preservation of life and property. On an airport, or in the immediate vicinity, this response is provided by the CFR fire-fighters, including the chief. Having the chief or one of his crew chiefs act as the OSC for an exercise does not allow the entire CFR unit to benefit, as fire-fighters, from the exercise. In the case of an emergency, it is not in the best interests of the occupants of the crashed aircraft, or in the advancement of aviation safety (preservation of evidence), to divert fire-fighters to duties other than those directly related to fire-fighting and evacuation. It is somewhat unfortunate that neither the Dryden airport supervisors, including the airport manager and the CFR chief, nor Transport Canada evaluators saw this as a problem. Had the duties and responsibilities of an OSC been defined better in the emergency plan, and those persons who could act as the OSC been named, it is unlikely that Chief Parry would have been acting as the OSC on March 10, 1989. He would have been acting as a fire-fighter and directing other fire-fighters, as required

by Transport Canada CFR policy documents, to fight the fire on C-FONF.

Town of Dryden

In his testimony, the mayor of Dryden, Mr Thomas Jones, was justifiably proud of the fact that he and other members of his council had attended the Emergency Preparedness College at Arnprior, Ontario. In fact, 16 municipal employees of the Town of Dryden, in addition to the elected members, had attended at least one of the courses at the college. In order to test its emergency plan, the Town of Dryden cooperated fully in planning and executing the exercises at the airport. Its participation in the Delta Four exercise resulted in a number of changes that assisted in the town response to the crash on March 10. In his testimony, Fire Chief Louis Maltais related what was learned from their participation in that exercise:

> At the November exercise ... we used a building – a room off of the police station as Emergency Control Room. And it was found at that time it was inadequate. There was too much traffic: security was a problem and a decision was made after this exercise to move to a room in the fire hall.
>
> And it was also identified at the time of this exercise that we did not have enough telephone phones, outside lines. So, from that, we installed extra telephones in this other room.
>
> We also found that radio communications were very poor. We couldn't ... contact the airport from where they ... had a command post. So that was recognized.
>
> So, we established a communications committee who, in turn, worked with the amateur radio group and from there we established them as a group of people that we would certainly be using in the event of an emergency.
>
> (Transcript, vol. 4, pp. 100–101)

Having learned some lessons in November before the accident in March, the Town of Dryden had moved the location of their control centre to the fire-fighter's lounge in the fire hall, installed new telephone communications, and was working to improve the radio communications.

Observations

I am struck by the difference between the Town of Dryden and the CFR unit at the Dryden airport in reaction to the problems encountered in the Delta Four exercise. The town made changes based on deficiencies noted during the exercise. The CFR unit was to make many of the same mistakes again.

It seems that Transport Canada, despite the fact that it subsidizes airports such as Dryden, is reluctant to use its fiscal power to ensure that problems identified in exercises are corrected by the personnel involved. In 1988 during Delta Four, some of the same problems were identified as in the Bravo Two exercise of 1985. In an area as critical as crash, fire-fighting, and rescue, there should be no reason for professionals to make the same mistakes in two consecutive exercises.

Evidence was produced which showed that, at both Thunder Bay and Dryden, real incidents were substituted for exercises for reporting purposes. Although this substitution is permitted, in the case of the Dryden HS-748 incident there was, in fact, no accident. Emergency services were called out to deal with an anticipated problem, but the aircraft landed safely. Accordingly, there was no need for any site coordination, fire-fighting, or rescue. Based on the evidence, if this emergency had not occurred, Dryden would not have had even this limited test of its emergency response systems in 1987.

The evidence before me indicated that Chief Parry never assumed a fire-fighting role during the exercises. He usually acted as an evaluator, and on the one occasion he was a participant in an exercise, he was the acting airport manager and was therefore removed from the actual exercise "crash site." It would seem that, if an exercise is meant to simulate a real event, all personnel should play the roles that they are expected to fulfil in an emergency.

During the hearings, I heard a great deal of testimony regarding the responsibilities of various agencies within the critical rescue and fire-fighting access area (CRFAA) and I expected that, if Dryden had had an approved airport emergency manual, it would have delineated these responsibilities. However, I have reviewed the Thunder Bay Airport Emergency Procedures Manual (Exhibit 202), which has been approved by Transport Canada, and could find no reference to the CRFAA. In fact, in referring to off-airport crashes, the manual states:

> A) Airport [sic] crashes off airport will be under the authority of the Municipal Authority or the Police Force for that area.

The clear impression I received from reading this approved manual was that the airport CFR unit would only be responsible for aircraft crashes on the airport property itself. Indeed, the manual shows a series of five-mile-diameter rings around the airport and describes what equipment may be sent from the airport CFR depending on the distance. It notes that CFR will respond "if requested" to a crash in the immediate vicinity but off the airport, and only "if it has been determined that the crash site is accessible and CFR can provide a useful service."

Although Transport Canada clearly defines what a CRFAA is, that by definition there is a CRFAA at every airport, and that there are prescribed requirements regarding the responsibilities of the CFR unit within a CRFAA, it is apparent that Transport Canada has not been rigid in requiring that airport managers adhere to the principles and practices regarding CRFAAs. As well, at least in the example in evidence, Transport Canada did not require that information pertaining to the CRFAA be included in airport emergency manuals. As the basis for the CRFAA is that most aircraft accidents occur within the area so described, it is my opinion that the response to aircraft crashes that occur within the CRFAA should be clearly delineated in all related documentation, including the airport emergency response plans.

The Emergency, March 10, 1989

Implementing the Emergency Plan

The Emergency Plan for the Town of Dryden is very clear on how an emergency should be declared and by whom:

> (a) This plan will be implemented as soon as an emergency occurs or is expected which is considered to be of such magnitude as to warrant its implementation.
> (b) This decision shall be made by the member of the Emergency Operations Control Group who received the initial warning and/or arrives first on the scene of the emergency.
> (c) At this time, this official will activate the alerting system, in whole or in part, be [sic] calling the Town of Dryden Police dispatcher, identifying himself, and giving all necessary and pertinent information and requesting that Operations Control Group be alerted.
>
> (Exhibit 31, pp. 4–5)

The chief of the CFR unit at the Dryden airport is not listed in the emergency plan as one of those with authority to activate it. Chief Parry's radio transmission on March 10 was heard, however, by the Dryden fire chief, Mr Maltais, and the police chief, Mr Russell Phillips. Both of these men were members of the control group and, recognizing that the emergency was the type envisaged by the Peacetime Emergency Plan, they immediately activated the plan. Given the remoteness of the crash site from the town centre, the immediate call by Chief Parry to the Dryden police dispatch resulted in coordinated aid reaching the site in the shortest possible time. In this action, Chief Parry reacted in a responsible manner to be expected of a fire chief.

Within 10 minutes of Chief Parry's call, the police dispatch had called the Dryden and UT of O fire-fighters, the police chief had begun notifying other agencies, the emergency control room had been set up, the control group had been assembled, and the control group had made contact with Chief Parry at the crash site.

All calls by telephone or radio that are received by the Dryden police dispatch are recorded on an eight-track Dictalogue tape system. There are individual tracks, or channels, for all incoming and outgoing police telephone calls, 911 emergency calls, police radio calls, and fire department radio transmissions. The Dryden Fire Department radio frequency, called the fire channel, was the frequency to use for any mutual aid requirement. On the day of the crash, this frequency was used by the majority of the agencies that responded to the crash. The OPP, unfortunately, do not have the equipment to broadcast or receive on this frequency. A separate tape track records time, which when played against the other tracks allows the timing of events. The fire channel tape was checked against the time track and, unless otherwise noted, this record (Exhibit 1282) has been used to verify times used throughout this Report.

Chief Maltais and the Dryden Fire Department

Fire Chief Maltais testified as to his actions after he heard Chief Parry's transmission at 12:14 p.m., a time when he was at his home for lunch. On hearing the radio transmission, he drove to the fire hall and went upstairs, where he knew most of the people who would make up the control group were assembled for a lunch. He called Mr John Callan, the town administrator, out of the meeting and informed him of the emergency. Mr Maltais then proceeded to the police office and ascertained that the chief of police was also informed. Proceeding to the fire-fighter's lounge, Chief Maltais began organizing the control centre, and he called the Dryden Telephone Company to ask for delivery of the telephone hand sets.

Chief Maltais then used the radio in a fire department vehicle to make contact with Red 3 at the site. In his initial transmission, made at 12:24 p.m., just 10 minutes after the original call declaring the emergency, Chief Maltais reported: "We have the control centre set up. You can make requests if you wish" (Exhibit 1282, p. 2). The radio in the truck remained the point of radio contact between the site and the town for the balance of the day.

At 12:27 p.m. Chief Maltais, at the request of Chief Parry, dispatched the Town of Dryden pumper truck, the suburban van that was usually driven by the chief and which contained rescue equipment, and 10 men to the crash site. These two vehicles, Dryden Fire 3 and Dryden Fire 5, arrived at the McArthur Road location at 12:44 p.m.

The UT of O Fire Department

Since the crash occurred in an area serviced by the UT of O Fire Department, Dryden dispatch called out the volunteers of that department. The fire-fighters responded quickly to the announcement. The chief, Mr Roger Nordlund, was at his place of business next door to fire hall number 1 when the announcement came. He opened the hall and, shortly after, two fire-fighters left it with the rapid attack unit. Mr Gerald McCrae then arrived at the fire hall and was dispatched with the tanker truck. Other members of the department proceeded directly to the scene in their private vehicles.

Chief Nordlund testified that he heard the alerting message only once and, since it was not repeated two more times as was the procedure in an emergency, he assumed that this was an exercise. On that assumption, he returned to his place of business, where he received a telephone call from Dryden dispatch asking for confirmation that the message had been received. Now convinced that this was an emergency, he got into his private vehicle and proceeded to the scene.

Many others who responded to the scene also felt they were attending an exercise. The scenario for the exercise that had been held the previous November involved an aircraft crash at the airport. Following that exercise, there had been some discussion of holding another exercise without giving the participants advance warning.

The first of the UT of O fire trucks reached Middle Marker Road at approximately 12:34 p.m., and the tanker truck driven by Mr McCrae arrived at approximately 12:40 p.m. Leaving their trucks parked on McArthur Road, the fire-fighters of the UT of O then proceeded to the crash site, where they assisted the survivors. Mr McCrae, in fact, after helping to carry Mrs Nancy Ayer out of the bush, ended up driving the ambulance that carried her to the hospital, leaving the site at 1:05 p.m.

It was sometime after 1:30 p.m. before the UT of O trucks were driven down Middle Marker Road and set up to begin fire suppression activities. A handline was taken through the bush from the UT of O pumper and the first foam was put on the fire at approximately 2:00 p.m.

The Ontario Provincial Police

The radio log of the Dryden Detachment of the OPP for Friday, March 10, shows that the first officer dispatched to the scene was Sergeant Douglas Davis at 12:17 p.m. The detachment had been notified of the crash by a telephone call from the Dryden police dispatch.

Sergeant Davis was in his vehicle when he received the dispatch. He immediately proceeded to the airport since, during the exercise that had been held in November 1988, the OPP had established a command post at the terminal. He arrived at the airport terminal at 12:25 p.m. and went

inside to speak with Mr Peter Louttit, the airport manager. After a brief conversation, Sergeant Davis proceeded to the crash site.

At 12:30 p.m., while en route to Middle Marker Road, Sergeant Davis asked his dispatch to find out if the local ham radio club had been notified. As a result of the November 1988 exercise, a demonstration of the club's capabilities to assist in such an emergency was scheduled for later in March, but Sergeant Davis decided they should be called on for this emergency. Coincidentally, the same decision was reached at the control centre and the Reverend Ken Rentz of the ham radio club was asked to gather the members.

On reaching the intersection of McArthur Road and Middle Marker Road at about 12:30 p.m., Sergeant Davis noted that injured passengers from the aircraft were arriving at the intersection. Private vehicles began to arrive and the injured were put in these cars and trucks for transport to the Dryden hospital.

At 12:34 p.m., Sergeant Davis asked that check points be established at both ends of McArthur Road to restrict vehicular access to the site. He spoke to Chief Parry while he was at the intersection, and at 1:00 p.m. he took a portable OPP radio and went into the bush to the crash site. At this point, he no longer had any method of direct communication with Chief Parry.

While at the scene, Sergeant Davis called for "CPFP [Canadian Pacific Forest Products] Ltd. personnel with chainsaws." He also radioed that "medical staff at scene require helicopter to scene asap re medical drop." At about the same time, similar requests were being made through the control centre. Because the OPP radios could not be connected to the frequency being used by Chief Parry and the Dryden control centre, there were two groups separately looking for the same kinds of resources. In addition, unknown to either Sergeant Davis or Chief Parry, a rescuer, Mr Mark Beasant, using a portable VHF aviation band radio, contacted Kenora FSS and asked them to relay his requests for certain supplies. These various independent requests resulted in more materials being requested than were actually required. Other than causing some congestion on McArthur Road, these duplicate requests did not affect the outcome of the rescue or fire-fighting efforts on the day of the crash.

Dryden Ambulance Service

When the call was received by the hospital emergency desk regarding the crash, ambulance unit 644, driven by Mr Ernest Kobelka with Mr Harold Rabb, the supervisor of the ambulance service with him, was on the road; they drove immediately to the accident area. The second Dryden ambulance, unit 645, was driven to the site by ambulance attendant Sandra Walker who, after receiving the call at her residence, proceeded to the hospital and loaded the ambulance with required

supplies. She left the hospital at 12:42 p.m. with doctors Alan Hamilton and Gregory Martin, and arrived at the scene at 12:55 p.m.

All times quoted in this section are based on three sources: the tachograph charts that were taken from the ambulances at the end of the day, notes made by Mr Kobelka and by Ms Walker, and the dispatch recording of the fire channel. From a comparison of these sources, it has been concluded that the tachograph chart from ambulance 644 was approximately nine minutes fast. Applying the estimated nine-minute error, the first ambulance, unit 644, arrived at the intersection at 12:35 p.m.

While a number of injured passengers were transported to the hospital in private vehicles, the most seriously injured were transported by ambulance. In the case of the two passengers who subsequently died from their injuries, Mrs Nancy Ayer was transported in unit 645, accompanied by attendant Walker, leaving the scene at 1:05 p.m. and arriving at the hospital at 1:15 p.m. Mr Michael Kliewer was also transported in unit 645, leaving the site at 1:45 p.m. and arriving at the hospital at 2:00 p.m.

Response Times

A number of people in Dryden at first assumed that the accident was an exercise. Given their initial incredulous reaction, the response from the responding emergency agencies seems remarkable.

Within 10 minutes of the emergency being declared, all required emergency services were notified, the control centre was established, radio contact was established with the accident scene, and the chief of airport CFR and one fire-fighting vehicle were on the scene. Within 20 minutes of the emergency call, the OPP were on the scene, road blocks had been established, and the first UT of O fire truck and the first ambulance had arrived at the intersection.

At the Scene

On-Site Coordinator

At the time of the accident, the Dryden Airport Emergency Manual was unapproved by Transport Canada, but it was still the only manual available. The manual described the duties of the on-site coordinator (OSC) for an aircraft crash on the airport; however, there is no description for the duties of an OSC in the case of an off-airport crash, nor is there any mention of the position of OSC in the Town of Dryden emergency plan. The duties of the OSC as listed in the airport Emergency Procedures Manual are as follows:

Action of On-Site Co-ordinator (OSC)

1. Assess situation and report to E.C.C. [Emergency Co-ordination Centre] via radio. Request any necessary resources.
2. Establish command post at suitable vantage point.
3. O.S.C. is responsible for overall command of site and responding agencies on site.
4. Direct activities of responding agencies through proper chain(s) of command.
5. Maintain record of all survivors and casualties leaving site and of all significant events.
6. Liason [sic] with O.P.P. site command post.
7. Turn over command of site to O.P.P. when area is secured from fire or other hazards.

(Exhibit 51, p. 9)

Section 3.00 of the manual comments on jurisdiction for off-airport crashes as follows:

> Aircraft accidents/incidents outside of the airport boundaries are the responsibility of the O.P.P. and the site will be under their command.
>
> (Exhibit 51, p. 14)

When Chief Parry arrived at the intersection of McArthur Road and Middle Marker Road, he opened the gate and sent crew chief Stanley Kruger in Red 1 down Middle Marker Road towards the crash site. As the first professional fire-fighter on the scene, Chief Parry remained at the intersection, assuming the position of the OSC, with his vehicle, Red 3, serving as the command post and marker for other responding vehicles and persons. He established communications with other agencies using the radio in his vehicle, set on the mutual aid frequency. At 12:19 p.m. Chief Parry contacted Dryden police dispatch by radio and gave directions to responding agencies. He then asked dispatch to let the OPP know that the aircraft was back in the bush and that helicopters, snow machines, snowshoes, and similar equipment would be needed.

At 12:24 p.m. he made the same requests of Mr Loutitt at airport control, remarking, "We can't get in with our vehicles at all" (Exhibit 1282, p. 2). In the next few minutes, contact was made with Chief Maltais at the control centre in town and Chief Parry requested men and fire-fighting equipment. In another call to the airport control, Chief Parry asked for some of the "field maintenance guys ... and at least a [front-end] loader," as well as blankets from the emergency kit in the fire hall.

When Sergeant Douglas Davis of the OPP arrived at the intersection at about 12:30 p.m., he had a brief conversation with Chief Parry and was informed he was the first OPP officer on the scene. Sergeant Davis

then assumed traffic control and began to assist with arranging transportation of the injured to the hospital. This is the traditional role assumed by the police at a fire scene until the fire is extinguished. Until that time, unless security or preservation of life is involved, the police leave the site in the control of the fire department.

At 12:34 p.m. the first UT of O fire truck arrived, followed closely by the first ambulance and the second UT of O truck. From their testimony, it seems clear that, for everyone who arrived on the scene, first aid and preservation of life was the first instinct. Chief Parry called for blankets and ambulances. Sergeant Davis put people in his car and arranged for private vehicles to take the injured to the hospital. The UT of O fire-fighters, according to the testimony of Mr Kobelka, gave first aid to the injured who gathered at their truck on McArthur Road. Mr McCrae, the driver of the second UT of O truck, took backboards and blankets into the woods and then drove an ambulance to the hospital.

A second fire chief, Mr Nordlund of the UT of O, arrived on the scene at approximately 12:45 p.m. On his arrival, Chief Nordlund had a brief conversation with Chief Parry to ascertain what had been done and then, as he related in his testimony, he went towards the crash site "to assess the fire" so his men could most efficiently combat it.

From the evidence, Chief Parry was doing an effective job as the OSC in informing others, requesting supplies, and coordinating activities at the intersection. However, he did not, at any time, direct the activities of the CFR or other fire-fighters.

Much time was spent during the hearings discussing the question of jurisdiction and the boundaries of the critical rescue and fire-fighting access area (CRFAA). It seems clear from the evidence that those persons responding to the accident saw the security of the site as an OPP responsibility. The responsibility for fire suppression rested with the UT of O Fire Department. Because an aircraft was involved and the accident was close to the airport boundaries, the airport CFR had an obligation to respond to the crash. Because they were first on the scene, the CFR chief assumed the responsibility for coordination and communication while he sent his crew chief to the crash site. On March 10 Chief Parry remained in or around Red 3 acting as the OSC, and explained that he did so based on experiences from past exercises.

Sergeant Davis testified that, when he arrived at the scene, there was no question in his mind that the accident site was "within OPP territory." As the senior officer and the first officer at the site, he was therefore in command until relieved. His first priority, in accordance with OPP policy, was the "preservation of life, [and] assistance to the injured" (Transcript, vol. 6, pp. 11, 13). Since injured passengers were coming out of the bush, he found shelter for some and arranged transportation to the hospital in private vehicles for others. At 12:34 p.m.

he called for roadblocks to be established and requested the assistance of other officers to ensure site security.Sergeant Davis did not address the issue of jurisdiction, nor did Chief Parry ask Sergeant Davis to relieve him as the OSC. In fact, the actions taken by each of these men may have been as a result of training and, in the case of the OPP, assuming the accepted role of the police at a fire scene. During each of the exercises held at the airport, a member of the CFR crew acted as on-site coordinator. In each of those exercises, the evaluator criticized the OSC for not remaining in one place, and preferably near the access road to the site.

From his testimony, we know that when Chief Parry did leave his command post at about 3:30 p.m., it was to turn over command of the site to Staff Sergeant D.O. Munn of the OPP.

The roles of Chief Parry and Sergeant Davis were accepted by all persons who responded to the crash, and, at the time, no one questioned their roles. Without criticizing what Chief Parry did as the OSC, as discussed in chapter 9 of this Report, Crash, Fire-fighting, and Rescue Services, or what Sergeant Davis did as the first OPP officer at the scene, it is my opinion that Chief Parry should have devoted his time and talents to fulfilling his responsibilities as the chief of Dryden airport CFR, as outlined in documentation pertaining to airport CFR services.

Communications

Various Transport Canada witnesses testified that one area that consistently causes problems in disaster response exercises is that of communications, and communications had been identified as a problem in the various exercises held at the Dryden airport. Following the Delta Four exercise at Dryden, a committee had been set up to improve communications. A mutual aid frequency had been designated, and all agencies were to switch to the mutual aid frequency in case of an emergency. Chief Parry switched to this mutual aid frequency on his way to the crash site. It was on this frequency that he requested Dryden dispatch to activate the mutual aid and emergency plan.

All radio communications between Chief Parry and the control centre were made through the Dryden Fire Department truck parked outside the fire hall. A runner then relayed requests between the truck and the control group. Since the crash, the Dryden Amateur Radio Club has installed permanent antennas on the fire hall, the airport terminal building, and at the hospital. Direct communications among the control group at the fire hall and the other two locations are now available.

The tape recording from Dryden dispatch shows that Chief Parry was able to communicate with the Dryden control centre, Dryden Fire Department vehicles, Dryden Fire Department portable radios at the site, and the airport control. By using another radio in his vehicle, he could

also speak with Kenora Flight Services and, later in the afternoon, directly with helicopters as they arrived in the area. However, the on-scene communications can best be described as chaotic in a number of respects. Chief Parry should also have been able to speak directly with his crew chief, Stanley Kruger, but Mr Kruger was using a different radio channel (see chapter 9, Crash, Fire-Fighting, and Rescue Services) and neither Chief Parry nor Mr Kruger switched channels in an effort to make contact, vital to the orderly control of this operation.

Throughout the emergency, the OPP operated on their own radio frequency, unable to communicate on the mutual aid frequency, and therefore unaware of the decisions of the control group. This problem was not unique to this situation. In any emergency situation that might have involved cooperation between the OPP and the Dryden Police Force, there was no way for the two to coordinate their activities on one frequency. The OPP plans to install a new radio system in Dryden in 1992 that should eliminate this shortcoming.

There was no direct communication by anyone with the members of the UT of O Fire Department, or their chief, throughout the afternoon. Although the UT of O had portable radios on order, they had not yet been delivered. (The portable radios were delivered to the UT of O Fire Department the week after the crash.) When the UT of O set up its port-a-pond, brought a handline through the woods, and began to suppress the fire, they had to use OPP portable radios at each end of the line to order the flow turned on and off.

On his way to the site, Sergeant Davis asked to have the ham operators alerted to assist in communications between agencies. As the emergency developed, Chief Parry had difficulty receiving information from the crash site. His crew chief was on the wrong channel, and the UT of O fire-fighters had no radios. At 1:01 p.m. the control centre dispatched a ham operator to try to plug this communications gap. Unfortunately, as the ham operator was going into the site to establish radio contact with Chief Parry, he was turned back by an OPP officer who was not aware that the operator had been sent to assist. Since the arrangement for this operator had been made on the mutual aid frequency, the OPP had no knowledge of the arrangement and assumed the operator was not authorized to enter the scene. This misunderstanding was soon rectified, and the ham operator was allowed into the scene.

If the OPP had relieved Chief Parry as the on-site coordinator, the police would have had to use Red 3 as their command vehicle or borrow radios in order to maintain direct communications with the majority of the rescue workers, the control centre in Dryden, and the airport control.

Had Mr Kruger and Chief Parry established radio contact when Mr Kruger first arrived at the crash site, handlines may have reached the wreckage and been used on the fire earlier than they were. The plight

of Messrs Kliewer and Teubert may have been eased, and perhaps the flight recorders would have been saved from destruction by the fire; certainly more of the aircraft wreckage would have been saved as evidence. This scenario, of course, presupposes that action in response to Mr Kruger's request for handlines would have been timely.

Fire Suppression

This section deals primarily with the response by fire-fighters to the crash. A detailed description of the aircraft fire and the activity of the fire-fighters regarding the fire is discussed in chapter 9, Crash, Fire-fighting, and Rescue Services, and chapter 11, Aircraft Crash Survivability.

Transport Canada CFR standards document AK-12-03-001 states:

> The primary objective of Crash Firefighting and Rescue Services (CFR) is to save lives in the event of an aircraft accident/incident or fire at an airport. This will be accomplished by providing a fire-free escape route for the safe evacuation or rescue of passengers and crew. A secondary objective is to preserve the property involved by containing or extinguishing, where practical, any fire resulting from an aircraft accident or incident.
>
> (Exhibit 243, p. 1)

The following timeline sets out when fire-fighting vehicles and fire-fighters arrived on the scene:

- 12:18 Chief Ernest Parry arrives at the corner of McArthur Road and Middle Marker Road in Red 3.
- 12:19 Red 1 arrives at end of Middle Marker Road, driven by CFR crew chief Stanley Kruger.
- 12:34 UT of O rapid attack truck arrives and parks on McArthur Road.
- 12:40 UT of O tanker truck arrives.
- 12:43 Red 2 arrives.
- 12:44 Dryden Fire 5 and Dryden Fire 3 arrive.
- 12:45 UT of O Fire Chief Roger Nordlund arrives.

Throughout the CFR portion of the hearings, the question of the timeliness of the arrival and use of handlines at the fire scene was discussed. It is important to determine the earliest time that handlines could have arrived at the scene, and whether earlier use of the handlines would have affected the fate of any of the passengers or crew.

From the evidence regarding the fire-fighting capabilities of the vehicles that responded, there is no doubt that by 12:45 p.m. there were enough equipment and personnel in the area of the crash to deal effectively with the fire. However, no one attempted to use any of the

equipment until approximately 1:30 p.m., when the UT of O pumper truck was moved down Middle Marker Road.

The UT of O rapid attack vehicle (pumper truck), the first fire-fighting vehicle to reach the scene that could have had an effect on the fire, arrived at the intersection of McArthur Road and Middle Marker Road at approximately 12:34 p.m. Mr Nordlund, the UT of O fire chief, stated in testimony that it would take one fire-fighter and two or three volunteers less than five minutes to extend 500 feet of hose, in four 100-foot and two 50-foot lengths, to the crash site. Mr Stanley Kruger, in his testimony, estimated that it would have taken up to half an hour to lay such a line through the deep snow, but reduced this estimate to 15 minutes if sufficient help was available. Assuming that other fire-fighters and volunteers assisted in this task and allowing time for the vehicle to reach the site and an assessment to be made, I estimate that a handline could have reached the aircraft wreckage by about 12:50 p.m. at the earliest. This estimate may be optimistic, since the trail to the wreckage was through deep snow.

I therefore considered the evidence regarding the state of the passengers at 12:50 p.m. to determine whether, if fire suppression had begun at that time, any deaths might have been prevented.

Two persons who survived the crash died later because of their injuries. Mrs Nancy Ayer died in a Winnipeg hospital of extensive burns received in the aircraft fire, but she was out of the aircraft wreckage before the first fire-fighter even arrived at the scene. In her case, the use of a handline by 12:50 p.m. would not have affected her fate. Mr Michael Kliewer died in the Dryden hospital with his cause of death listed in his autopsy report as massive trauma, which he sustained in the crash. Again, the use of a handline would not have saved his life; however, the timely use of the handline may have reduced his burn injuries. A third person, Mr Alvin Rossaasen, died in the wreckage, his autopsy indicating that he died from smoke inhalation (carbon monoxide poisoning) and burns. The lethal level of carbon monoxide that was found in his body can be reached over a time period of 2 to 30 minutes. Mr Rossaasen was trapped beneath another passenger on the left side of the aircraft, where the fire was the most intense. As the crash occurred at 12:11 p.m., there is little doubt that Mr Rossaasen was dead before 12:50 p.m. Finally, Mr Uwe Teubert, who survived the crash and was found trapped under Mr Kliewer at about 1:10 p.m., may have suffered less had the handlines been in use earlier.

The autopsy reports for the other deceased persons indicate that, while a number of the deceased showed evidence of smoke inhalation, all of these persons were dead within minutes of impact. Therefore, the issue of handlines is not relative to their fate.

Dr Martin testified that he arrived at Middle Marker Road in ambulance unit number 645, whose tachograph indicates the arrival time to be 12:55 p.m. He then proceeded to the scene, and he testified he did not believe that there was anyone, besides Mr Kliewer and Mr Teubert, still alive in the aircraft. In their testimony, Sergeant Davis and Chief Nordlund, who arrived at the scene at approximately 12:30 p.m. and 12:45 p.m., respectively, state that besides Mr Kliewer and Mr Teubert, no other passengers were alive in the wreckage.

Although the earlier use of the handlines would not have affected the fate of the passengers who died as a result of the crash and fire, it is obvious that had the handlines been used earlier to suppress the fire, more of the important physical evidence could have been saved, including cockpit instrumentation and probably the information in the flight recorders.

To remove the recorders from the wreckage, the fire-fighters would have to have known their location. The UT of O fire-fighters who eventually did run the handline to the wreckage had no training regarding the location of various critical areas on an aircraft. Their primary responsibility in the case of a fire at the airport was fighting structural fires. CFR was to be responsible for aircraft fires. Unfortunately, even the CFR fire-fighters did not know the location of the flight recorders on the F-28 aircraft. In fact, the CFR unit did not have a crash chart for the F-28 that would have shown the location of the recorders. Even if the fire-fighters did not know the location of the recorders, simply spraying the entire aircraft to put out the fire may have cooled the recorders enough so that their tapes and the recorded information would have survived the heat.

The evidence indicates that the fire-fighters at the scene of the crash became distracted by the injured passengers to the extent that they overlooked their responsibility to fight the fire.

Crew chief Stanley Kruger, the first professional fire-fighter to reach the aircraft, gave up his fire-fighter's jacket to flight attendant Hartwick so she could keep a baby warm. This was a humanitarian act, but this jacket was an important part of his fire-fighting equipment if Mr Kruger had to approach the fire for either rescue or fire suppression.

Chief Nordlund of the UT of O Fire Department testified that he went in to the scene "to assess the fire," yet on the way to the fire he stopped to assist others. When he arrived at the wreckage, he assisted in the rescue of Mr Kliewer and Mr Teubert, even though at that time there were between 20 and 30 other fire-fighters on the scene. Chief Nordlund did not even don his fire-fighting clothing to go into the fire area.

There was a concerted effort on the part of all the fire-fighters to assist and provide comfort to the survivors. Most assumed when they arrived

at the crash that anyone who was not out of the wreckage was not going to get out. As Mr Kruger testified:

> Q. Mr Kruger, from your own observations and your own professional opinion as a fire-fighter who has been doing this work for some time, would you give the Commissioner your best opinion on whether there could have been any live passengers inside that fuselage at the time that you came upon it.
>
> A. I would have to state emphatically that, when I got there, there were no survivors in that aircraft, from my visual observations.
>
> (Transcript, vol. 26, p. 133)

If Mr Kruger's conviction was shared by all who arrived on the scene, it is understandable that the fire-fighters saw no need to provide "a fire-free escape route for the safe evacuation or rescue of passengers and crew." Nevertheless, the fire-fighters, and especially the members of the CFR unit, had a responsibility to "preserve the property involved by containing or extinguishing, where practical, any fire resulting from an aircraft accident or incident." Their inaction in responding to this part of their mandate probably cost the investigators the irreplaceable evidence contained in the flight recorders that would have been of value in the aircraft accident investigation and for the prevention of future aviation accidents.

Provision of the Passenger List

The time taken to compile a list of names of both victims and survivors of the crash was a subject of controversy both at the time of the crash and during the hearings of this Commission. Initially, for the rescuers, the total number on board the flight was an important piece of information. An accurate number, 69, was given to Chief Ernest Parry by the airport manager at 12:46 p.m., 35 minutes after the crash. This number was immediately available when requested by Chief Parry.

The first list of passenger names, sent by Air Ontario to the OPP, was received at approximately 4:00 p.m. on March 10. This list contained 57 names and was not an accurate list of the passengers on board at the time of the crash. An accurate list was received by the OPP at 8:00 p.m. the same day. This list was compiled by obtaining the names of the Air Ontario and Air Canada passengers who boarded in Thunder Bay, adding the names of those from the cancelled Canadian Partner flight who joined flight 1363 in Thunder Bay, and then checking for the names of passengers who left or joined the flight in Dryden.

A more timely provision of the passenger list at Dryden would have assisted the hospital in the treatment of injuries and the Red Cross, which was dealing with family inquiries. However, since this list was

also used to notify the families of the deceased prior to the removal of the bodies from the wreckage, it was important that it be accurate. Even with the care taken to ensure accuracy, the media reported that one man, who had the same name and province of residence as one of the passengers, was incorrectly notified of that passenger's death.

Given the fact that passengers from another airline were added to the flight in Thunder Bay and that some passengers left and others joined the flight in Dryden, Air Ontario clearly required time to verify the list. Since it was to be used to notify next of kin, any requirement for speedy provision of the list must be balanced by the need for accuracy before families are contacted.

Of greater concern was the length of time taken to release the passenger names to the public. There can be no argument that the next of kin must be notified before any list of the deceased is circulated. In this case, however, all next of kin had been notified by late Saturday, March 11. A partial list of passengers was published in the *Toronto Star*, on March 15, five days after the crash, but, even then, it was not released by the OPP. Inspector Frank Harvey of the OPP refused to release the names until positive identification had been made at the post-mortem. In addition, he told the media that the list was the property of Air Ontario. It appears that, in the end, the list published was inadvertently released to the media by the OPP.

In the case of any accident, the release of the names of the victims is the responsibility of the investigating police agency. Once the police have contacted the next of kin, there should be no reason for withholding the names of the victims. In this case, the unreasonable delay in releasing the names resulted in the media's publishing their own partial list before an accurate one was made available.

Other Dryden Agencies and Businesses

Evidence was heard in Dryden regarding the significant contributions that were made by the Red Cross, the Dryden Welfare Office, the staff of the Dryden hospital, many Dryden businesses, and many individuals. All were part of a coordinated town response of which the citizens of Dryden can feel proud.

Of course, as with any disaster for which there is planned response, some things happen that were not anticipated in the emergency planning. The Town of Dryden held a number of meetings after the crash to discuss the various responses to the emergency and to learn from their experience. Attached as appendix I are the minutes of the meetings held on March 13 and 16. At these meetings, the citizens of Dryden explained the problems they encountered and assessed the effectiveness of the response to the disaster. These minutes, more than

any report I could write, demonstrate the involvement of the town and the problems the townspeople encountered. I recommend that officials of other Canadian towns and cities read these minutes with their own emergency plans in mind and learn from the experiences of the Town of Dryden.

Findings

- The Dryden Municipal Airport Emergency Procedures Manual, first submitted to Transport Canada on January 29, 1988, had not been approved by Transport Canada on March 10, 1989. The manual had not been approved because the Dryden airport officials had refused to implement changes to the manual suggested by Transport Canada, and Transport Canada had not insisted that the manual be prepared to Transport Canada standards.

- Because the Dryden Municipal Airport Emergency Procedures Manual had not been approved, a copy of it, even in draft form, was not in the hands of appropriate agencies, such as the Kenora Flight Service Station.

- The Dryden airport CFR unit apparently was reluctant to carry out training exercises in winter, a reluctance that ignores the fact that aircraft crashes can and do occur in winter weather conditions.

- The crash of Air Ontario F-28 C-FONF occurred within the boundaries of the Dryden airport CRFAA.

- Transport Canada defines a CRFAA. By definition there is a CRFAA at every airport and there are prescribed requirements regarding the responsibilities of the CFR unit within a CRFAA, but it is apparent that Transport Canada has not been rigid in requiring airport managers to adhere to the principles and practices regarding CRFAAs. As well, Transport Canada does not require that information pertaining to the CRFAA be included in airport emergency manuals.

- The chief of the Dryden airport CFR unit did not assume a firefighting role during the various exercises in which the Dryden CFR unit participated from 1985 to 1988. He acted as an evaluator, and on one occasion he was the acting airport manager. Accordingly, neither the CFR unit nor the chief himself benefited fully from the exercises. The CFR fire chief, because he acted either as an evaluator or was the airport manager at the time that a full-scale exercise took place, was

neither tested nor exercised as a fire-fighter or as an on-site commander.

- Transport Canada did not ensure that during exercises the chief of the Dryden airport CFR unit occupied a role that he would be expected to fulfil in an emergency.

- During exercises in which the Dryden airport CFR unit participated, CFR crew chiefs acted in the role of on-site coordinator rather than as fire-fighters.

- The role of the on-site coordinator was not clearly defined by Transport Canada.

- Transport Canada allowed CFR unit fire-fighters to act as on-site coordinators, diverting them from their roles as fire-fighters.

- Full-scale exercises at the Dryden Municipal Airport, involving the CFR unit, were not conducted regularly.

- CFR training exercises involving the Dryden airport, although inadequate, were helpful; however, deficiencies identified in the exercises were not always corrected.

- Transport Canada did not exercise its authority over the Dryden airport management to impose its national standards in the Dryden Municipal Airport Emergency Procedures Manual.

- Transport Canada did not ensure that the matter of the Dryden airport CRFAA was clearly defined in the Dryden Airport Emergency Procedures Manual and understood by the Dryden CFR chief and personnel.

- The Dryden airport CFR access road to the CRFAA was inaccessible to CFR vehicles on March 10, 1989, owing to lack of winter maintenance.

- Two civilians, Mr Craig Brown and Mr Brett Morry, were the first persons to arrive at the crash site, having departed from the airport terminal immediately after seeing the fireball from the crash. They made a path from Middle Marker Road, through deep snow, to the aircraft.

- Dryden CFR Chief Ernest Parry arrived at the intersection of Middle Marker Road and McArthur Road at between 12:15 and 12:18 p.m. and set up a command post. Crew chief Stanley Kruger arrived in Red 1 shortly thereafter, parking at the far end of Middle Marker Road, approximately opposite to the crash site. He carried a portable radio and a first aid kit to the crash site, following the path made by Messrs Brown and Morry. He encountered some 20–25 survivors and directed them towards McArthur Road. The survivors reached McArthur Road at approximately 12:32 p.m.

- All survivors were out of the aircraft wreckage by the time Mr Kruger reached the crash site, except for Mr Uwe Teubert and Mr Michael Kliewer, who were trapped on the left side of the aircraft under wreckage until freed at approximately 1:12 p.m. under the direction of doctors Gregory Martin and Alan Hamilton, who had arrived on the scene.

- The initial response to the crash of C-FONF on March 10, 1989, by the various emergency plan agencies, Ontario Provincial Police, Town of Dryden Fire Department, Unorganized Territories of Ontario Fire Department, Dryden Ambulance Service, and Dryden CFR services unit, was timely and well executed. However, the fire-fighting activity at the scene was uncoordinated and lacking in leadership and direction.

- Although a mutual aid frequency had been designated in the Dryden Municipal Airport Emergency Procedures Manual, not all responding agencies had the equipment necessary to operate on that frequency.

- The on-scene radio equipment for communication between the fire chief, the fire-fighters, the OPP, and rescuers was either misused, incompatible, or nonexistent, clearly contributing to the lack of a coordinated and timely fire-fighting effort at the crash site.

- As was the case in previous full-scale emergency exercises, all Dryden area agencies responding to the crash on March 10, 1989, were not capable of communicating on a common frequency. The Ontario Provincial Police did not have the equipment necessary to transmit and receive on the channel designated in the Dryden Area Response Plan as the emergency fire (mutual aid) channel. Communication between CFR Chief Parry and CFR crew chief Kruger was not established in a timely manner on either the fire channel or the CFR unit working channel. The UT of O fire chief and fire-fighters had no radios for communication between themselves or anyone else.

- A substantial amount of fire-fighting equipment arrived on the scene between 12:19 and 12:44 p.m., more than sufficient to extinguish the aircraft fire.

- The obvious lack of coordination and direction of fire-fighting activity at the scene of the crash was caused at least in part by jurisdictional uncertainty, deficient training, and confusion as to who was in command.

- At the scene of the crash, all the fire-fighters, including the fire chiefs for the Dryden airport CFR unit and the UT of O Fire Department, became distracted by the plight of the survivors to the extent that they overlooked their primary responsibility to fight the aircraft fire. As a result, handlines were not brought in and fire extinguishant was not applied to the aircraft fire until approximately 2:00 p.m. on March 10, 1989, about one hour and 50 minutes after the crash.

- It is highly probable, if not virtually certain, that more timely extinguishment of the aircraft fire would have resulted in preservation of the aircraft data recorders and of more of the aircraft remains, for investigative purposes.

- Concentration by the fire-fighters at the crash site on their primary responsibility of extinguishing the aircraft fire and providing an escape route for passengers would probably have resulted in the earlier location and freeing of Mr Teubert and Mr Kliewer from the wreckage.

- The duties and responsibilities of the on-site coordinator (OSC) for an aircraft crash are not fully detailed in the Dryden Municipal Airport Emergency Procedures Manual. For example, the manual did not designate individuals holding certain positions among the various agencies involved in the emergency manual who would be expected to act as on-site coordinators. Although the manual described the duties of an OSC for an aircraft crash on the airport, the manual did not deal with a crash off the airport.

- Apart from the noted deficiencies in the fire-fighting response at the scene of the crash, the collective efforts of all persons, agencies, businesses, and officials in the Town of Dryden relating to the crash were timely and carried out in a responsible, compassionate, and meaningful manner.

RECOMMENDATIONS

It is recommended:

MCR 18[1] That Transport Canada ensure that airport crash, fire-fighting, and rescue units carry out emergency response exercises as mandated in applicable Transport Canada documentation, including exercises in winter and in off-airport conditions.

MCR 19 That Transport Canada ensure that all persons involved in crash, fire-fighting, and rescue (CFR) exercises, including CFR chiefs and on-site coordinators, fully understand and carry out their duties during such exercises, as defined in applicable Transport Canada documentation and as they would in an emergency.

MCR 20 That Transport Canada ensure that airports subsidized by Transport Canada have in place at all times up-to-date crash, fire-fighting, and rescue airport emergency response plans and airport emergency procedures manuals approved by Transport Canada.

MCR 21 That Transport Canada ensure that the necessary crash, fire-fighting, and rescue emergency response to aircraft crashes that occur within the critical rescue and fire-fighting access area (CRFAA) be clearly delineated in all relevant documentation, including airport emergency response plans and airport emergency procedures manuals.

MCR 22 That Transport Canada ensure that, as part of the emergency planning process, all responding agencies designated in an airport emergency procedures manual equip themselves with radios capable of communication on a common channel.

[1] In the course of the hearings of this Commission of Inquiry, certain facts emerged from the evidence that, in the interests of aviation safety, I felt duty-bound to report in two interim reports. For ease of reference, recommendations are numbered consecutively, beginning with those that appear in my *Interim Report* of 1989, and all are found in Consolidated Recommendations, Part Nine of this my Final Report. They are preceded by the code "MCR," in accordance with the "short title" (Moshansky Commission) of the reports.

PART THREE

CRASH, FIRE-FIGHTING, AND RESCUE SERVICES

9 DRYDEN MUNICIPAL AIRPORT CRASH, FIRE-FIGHTING, AND RESCUE SERVICES

In the introduction to my Report, I stated that in my view the involvement of the Dryden Municipal Airport Crash, Fire-fighting, and Rescue (CFR) Services was a collateral safety issue which I considered serious enough to warrant investigation.

Legislation and Policies Governing Dryden Municipal Airport and Its CFR Services

The Dryden Municipal Airport aerodrome certificate in effect on March 10, 1989, was issued on March 23, 1988, to the Town of Dryden by the minister of transport pursuant to the *Aeronautics Act* and the Air Regulations. This certificate requires the Town of Dryden to maintain an aerodrome operations manual for the Dryden Municipal Airport in accordance with the aerodrome standards contained in Air Regulations Series III, No. 2 – Airport regulations. Although aerodrome services do not form part of the aerodrome certification criteria, the aerodrome operations manual requires that aerodrome services provided be inventoried in the manual; CFR services are in this category. The Dryden Municipal Airport Aerodrome Operations Manual, approved by Transport Canada on March 23, 1988, lists CFR services as follows:

> 3.1 AERODROME EMERGENCY SERVICES – SERVICES D'URGENCE
>
> A) Crash, Fire Fighting and Rescue – Services de secours et d'incendie
>
> CFR4 – 2300 Gals of foam
> 400 Lbs dry chemical
>
> Hours of Operation – Heures d'exploitation as per CFS [Canada Flight Supplement]

B) Medical (Agreements with Other Agencies) – Médicaux (Ententes avec d'autres organismes)

1. First aid from AES [Airport Emergency Services]

There are no further requirements regarding CFR services listed in the aerodrome certificate or in the Aerodrome Operations Manual. As well, unlike United States Federal Aviation Regulations (FARs), in particular FAR Part 139, Canadian aviation legislation, such as the *Aeronautics Act*, Air Regulations, and Air Navigation Orders, has no provisions governing the requirements of CFR services.

FAR Part 139 deals with the certification and operations of United States land airports that service scheduled or unscheduled air carrier operations conducted with aircraft having more than 30 passenger seats. Parts 139.317 and .319 set out minimum levels of CFR equipment and extinguishing agents, and operational requirements that must be maintained at these airports. By legislation, aircraft rescue and fire-fighting equipment and extinguishing agents are defined by reference to Federal Aviation Administration (FAA) advisory circulars and must be acceptable to the administrator of the FAA. Similarly, by legislation, an airport's aircraft rescue and fire-fighting vehicles and their systems must be maintained so as to be able to perform their functions, and personnel must be able to demonstrate their ability to respond adequately when requested by the FAA. As well, each airport certificate holder must ensure that all rescue and fire-fighting personnel are acceptably equipped and properly trained to perform their duties in a manner acceptable to the administrator of the FAA.

In Canada, rules and guidelines governing crash, fire-fighting, and rescue requirements and standards are set out in various policy documents issued by Transport Canada Airports Authority Group. These policy documents, given AK designations, are implemented as mandatory standards and guidelines for internal use within Transport Canada. These documents are intended to govern Transport Canada – owned and operated airports but they have no supporting legislative or statutory authority.

The principal documents used by Transport Canada Airports Authority Group for CFR services are AK-12-03-001, CFR standards document, and AK-12-06-002, 003, and 004, training and equipment standards documents. Other related policy documents are AK-12-08-002, Firefighter Code of Conduct, and AK-66-06-400, Aviation Fuelling Manual. For information not contained in these documents, CFR firefighters must refer to documents called National Fire Protection Association (NFPA) manuals, published in the United States. For example, Transport Canada document AK-66-06-400 does not provide

information regarding the handling of fuel spills. NFPA manuals specifically describe and categorize sizes of fuel spills and how each spill is to be handled.

I find Transport Canada AK policy documents dealing with CFR services to be detailed and comprehensive. I also find Transport Canada training requirements to be of a high standard, with the exception of certain specific deficiencies that are dealt with in this Report.

Specific deficiencies were noted in the training and knowledge of the Dryden airport CFR personnel in a number of areas. Some of these deficiencies arose out of a lack of training requirements or policy instruction within the Transport Canada CFR documentation and training standards. I will deal with these deficiencies in the context of the activities of the Dryden CFR unit on March 10, 1989.

Unlike in the United States, no legislation in Canada compels certificate holders of airports not owned or operated by Transport Canada to comply with Transport Canada policy standards and guidelines regarding CFR services. An airport such as the Dryden Municipal Airport, which is owned by Transport Canada but leased and operated by the Town of Dryden, appears to fall into a category that is neither clearly governed by Transport Canada CFR policies and standards nor by legislation equivalent to such policies and standards. Transport Canada exercises certain control over the operation of the Dryden Municipal Airport through its lease and its financial assistance agreements. I will deal specifically with these agreements and their application to CFR services further in this chapter.

Background of Dryden Municipal Airport and CFR Services

In August 1968 the Corporation of the Town of Dryden and the minister of transport entered into an agreement for the construction, operation, and ownership of the Dryden Municipal Airport. The Town of Dryden acquired the land and constructed access roads, and Transport Canada constructed a runway, now a paved runway, 6000 feet long by 150 feet wide. In March 1974 the Town of Dryden transferred to the minister of transport all the land upon which the Dryden Municipal Airport is situated and, thereafter, has leased the airport for successive five-year periods. The most recent lease agreement is dated June 5, 1989. The relevant provisions in the agreement state as follows:

> 22. That the Lessee shall, at its own cost, before using the said land and the said facilities for airport purposes obtain a license from the Minister under the Air Regulations and amendments thereto, and

> thereafter the Lessee shall during the currency of this Lease operate the said airport as a public airport, subject to such terms and conditions as the Minister may direct and shall charge for the use of the said airport and for any services performed in connection therewith only such fees as the Minister may approve.
>
> 23. That the Lessee, its officers, employees and agents and all persons using the said airport, shall, at all times, during the currency of this Lease observe and comply with the provisions of the Aeronautics Act, as amended from time to time, the Air Regulations, and amendments thereto, all rules and regulations made from time to time pursuant to the said Act, and all local airport rules.
>
> (Exhibit 27, Lease Indenture, July 15, 1975)

The Town of Dryden views the Dryden Municipal Airport as a regional airport serving the surrounding area and northwestern Ontario. A number of flights feed into the airport from outlying areas to meet up with flights to Thunder Bay and Toronto or west to Winnipeg. There are approximately 6000 people in the Dryden community; however, up to 55,000 passengers use the airport annually.

The Dryden airport is managed by the Dryden Municipal Airport Commission on behalf of the Town of Dryden. The commission members are the mayor of the Town of Dryden, one town councillor, and two other town representatives. Mr John Callan, the chief administrative officer for the Town of Dryden, also acts as the secretary-treasurer to the commission. Day-to-day operation of the airport is the responsibility of the airport manager, who reports directly to the airport commission. Mr Peter Louttit was the airport manager from 1978 until December 15, 1989.

The airport commission enters into sublease agreements with various parties such as Dryden Flight Centre, Canadian Partner, and rental car agencies located at the airport. It is the view of the Town of Dryden and the airport commission that Dryden is not responsible for funding the airport in any way, and that operational losses are to be borne by Transport Canada. Airport revenues are primarily derived from leasing agreements and landing fees and are approximately $300,000 annually, while the total annual operating expense is approximately $900,000. The expenses (using approximate figures) are split among five centres as follows: administrative, $100,000; surface maintenance, which includes fuel maintenance, mobile equipment maintenance, and fuel and maintenance staff, $250,000; mechanical and plant maintenance, $100,000; security services, $100,000; and the CFR unit, $350,000. A large portion of the CFR cost is fire-fighters' wages. Transport Canada subsidizes the airport for the shortfall of approximately $600,000.

Each year, based on the forecast operating budget, the Town of Dryden applies to Transport Canada for financial assistance for the airport. Funding is governed by an agreement between the Town of Dryden and the minister. Clauses from the latest agreement, dated April 3, 1979, which are relevant to the operation of CFR services on the airport are as follows:

5. *Operating Subsidy*

   (1) Upon the Corporation's submission to the Minister of its forecast annual budget, Her Majesty will grant financial assistance to the Corporation by way of an annual operating subsidy to a level approved by the Minister and the maximum level of subsidy shall be determined annually in advance by the Minister.

7. *Ministerial Approval*

   The Corporation shall not, without the consent in writing of the Minister, being first had and obtained, assume any obligations or make any expenditures under the provisions of this Agreement which is not in accordance with annual operating budgets approved by the Minister.

9. *Air Regulations*

   The Corporation shall abide by the Air Regulations, including any amendments thereto, and all other regulations that may be made from time to time under the provisions of the Aeronautics Act, being Chapter A-3 of the Revised Statutes of Canada, 1970, and the Corporation shall obtain a licence from the Minister under the Air Regulations and amendments thereto, and thereafter the Corporation shall, during the currency of this Agreement, operate the Airport as a public airport, subject to the terms and conditions as the Minister may direct.

12. *Corporation Provision of Facilities*

   Without limiting or restricting the generality of the provisions of Clause No. 18 hereof, the Corporation shall be responsible for the operation, management and maintenance of the Airport, and all related facilities which, without limiting or restricting the generality of the foregoing, shall include airport services, runways, fences, hangars, shops, terminal and other buildings, airport lighting equipment, and like services, and the Airport shall be maintained in a serviceable condition, all to the satisfaction of the Minister.

13. *Navigational Aids, etc.*

   Her Majesty may supply radio navigational facilities, airway and airport traffic control and meteorological services should the Minister at any time consider that such services are necessary.

(Exhibit 288)

In the early years of this arrangement, it was relatively easy for the Dryden airport to obtain subsidies from Transport Canada. Since 1984, according to Mr Louttit, fiscal restraint has led Transport Canada to require more justification for assistance. Mr Louttit testified that fiscal restraint, together with ongoing reorganization, changed the relationship between Transport Canada and the Dryden airport, and that Transport Canada expected the airport commission to operate more independently. It was this arm's-length relationship that existed on March 10, 1989, and, according to Mr Louttit, the transition to independence was a difficult one both for Transport Canada and for the Town of Dryden, particularly at Mr Louttit's level of airport manager. The relationship between Transport Canada's regional office at Winnipeg and the Dryden Municipal Airport was at times strained, especially during budget negotiations.

Mr Callan, in his testimony, spoke with some pride about the Dryden airport and the significance it has for the business community and the local residents. It is my impression that the Town of Dryden and the airport commission also took pride in the fact that the airport was manned by full-time professional CFR personnel equipped to handle aircraft such as the Boeing 737.

There are 37 airports in Transport Canada's Central Region that are either owned and operated by Transport Canada, owned and subsidized by Transport Canada, owned by Transport Canada and operated under contract, or only subsidized by Transport Canada. Transport Canada, Central Region, covers the area from Thunder Bay to the Saskatchewan/Alberta border and from the Canada/U.S. border north to the high Arctic. In the early 1970s, flying activity was increasing and carriers such as Transair started flying into the Dryden airport using Fokker F-28 aircraft. NorOntair also operated Twin Otter aircraft into Dryden. In the late 1970s, sophisticated and expensive fire-fighting equipment was being placed at various subsidized airports across Canada, and Transport Canada was attempting to staff CFR units at these subsidized airports with fire-fighters in accordance with the prescribed airport category. Emergency services specialists in Transport Canada Central Region headquarters, Winnipeg, in allocating their resources, wanted to place at each of the subsidized airports a full-time professional fire chief so there would be someone at each airport to maintain the new fire-fighting equipment and to hire and train auxiliary fire-fighters. However, Transport Canada headquarters decided to concentrate the full-time professional fire-fighters at airports, such as Dryden, into which larger aircraft types were operating.

The Dryden airport commission began employing full-time fire chiefs in 1978. The first two fire chiefs that were hired did not remain for various reasons including, in the opinion of Transport Canada emer-

gency services specialists, frustration as a result of a perceived lack of support by the airport manager for the CFR program. Mr Ernest Parry, hired in 1982, was the third fire chief and was hired coincident with the Dryden airport CFR unit being staffed with full-time, professional fire-fighters.

Dryden Airport Category and CFR Services

Airport Categorization

Airports are categorized by Transport Canada for the purpose of determining the CFR resources required, based on length and maximum fuselage width of the longest aircraft normally using the airport. The airport category is determined from a table in Transport Canada document AK-12-03-001. The category appropriate to aircraft length is established first and, if the maximum fuselage width of the longest aircraft is greater than the maximum width for that category, the category is increased by one level. Aircraft traffic statistics for the previous 12 months are also used in determining the airport category.

Level of Protection

Transport Canada document AK-12-03-001 outlines the CFR requirements for all categories of airports. The categories range from 1 to 9, with an airport like Manning, Alberta, being a 1; Moose Jaw, Saskatchewan, a 3; Montreal/Saint-Hubert, Quebec, a 5; Winnipeg, Manitoba, a 7; and Lester B. Pearson in Toronto, Ontario, a 9. On March 10, 1989, the Dryden airport was listed as category 4.

The number, type, and characteristics of fire-fighting vehicles and minimum quantities of extinguishing agents are specified for each category. The minimum number of employees on duty is specified and related to the type and number of vehicles provided to meet the level of protection for the particular airport category. At airports of category 5 or above, the manpower response is to include one additional person as crew chief.

It is stated in document AK-12-03-001 that "Airport emergency procedures shall be developed to ensure the effective utilization of all available resources in the event of an aircraft accident/incident" (Exhibit 243, s. 4.01, p.7).

Dryden Airport CFR Services

From 1978 until March 10, 1989, the category of the Dryden airport varied from category 3 to 6. In the 1980s, Transport Canada monitored Dryden air traffic and determined that the category of the Dryden airport was too high. Transport Canada then discussed downgrading the category with the Dryden airport commission. During these discussions, the Dryden airport commission's aim was to maintain the highest airport category and the commensurate level of CFR services. Thus, CFR staff positions could be preserved.

It was the evidence of Mr Callan that Dryden area residents were thrilled when Air Ontario announced it was going to introduce its jet service to the Dryden airport. Accordingly, the Town of Dryden corresponded with Air Ontario to gain its support for maintaining the existing airport category and had discussions on the same topic with Transport Canada. The Town of Dryden and the airport commission wished, at least, to delay any reduction of CFR service.

The *Canada Flight Supplement*, in effect for the period February 9, 1989, to April 6, 1989, provided Canadian terminal and en route data for pilots in flight and for flight planning. It listed the Dryden Municipal Airport as a category 4 airport, with the appropriate level of CFR services available from 1300 to 0315 UTC (7:00 a.m. to 9:15 p.m. CST) on Monday to Saturday and from 1300 to 0300 UTC (7:00 a.m. to 9:00 p.m. CST) on Sundays. Outside these hours of operation, three hours' prior notice was required for CFR service.

Although the Dryden airport was listed in the supplement on March 10, 1989, as a category 4 airport, the CFR vehicle strength, a rapid intervention vehicle and a foam truck, was in fact commensurate with a category 5 airport. The Dryden CFR unit comprised a fire chief and five fire-fighters, all full-time professionals, two of whom were designated crew chiefs. Transport Canada AK-12-03-001 lists the CFR staff requirement for a category 4 airport as four professional fire-fighters and five auxiliary fire-fighters. Shortly before the March 10, 1989, crash, Transport Canada had advised the airport commission that the Dryden airport should be reclassified as a category 3 airport. This change, if implemented, would have effectively eliminated all full-time fire-fighters, except for the fire chief.

Nordair Ltd introduced jet service to the Dryden airport in the late 1970s, using the Boeing 737-100 aircraft. This was the largest aircraft to use the airport, and its size and the frequency of service resulted in the airport being assessed at that time, as category 6. Because of a subsequent reduction in the number of Boeing 737 flights into Dryden, the airport category was reduced to category 5. Canadian Airlines, the successor to Nordair Ltd, terminated the Boeing 737-100 service into

Dryden in February 1988. Air Ontario subsequently introduced jet service into Dryden, using the Fokker F-28 Mk1000 aircraft, in June 1988. This aircraft, which was smaller than the Boeing 737, required a category 5 airport, but, because of a lower frequency of service, the airport was then assessed as category 4. Without the operation of the F-28 aircraft, the Dryden airport could have been reduced by Transport Canada to a category 3 airport.

The chief of the Dryden airport CFR unit reports to the airport manager. The fire chief is responsible for managing the CFR unit. The evidence indicates that the chief's responsibilities include the following: ensuring that CFR employees are adequately trained and able to perform their duties; preparing annual work plans and budgets; requesting training materials through the airport manager from Transport Canada; and reporting CFR unit activities to the airport manager on a monthly basis.

Role of the Dryden CFR Unit

There were posted on the wall of the Dryden CFR unit office copies of two pages from A.I.P. Canada: Aeronautical Information Publication, TP 2300 E, dated May 13, 1982, and entitled "Airport Emergency Services," stating the following objective at Paragraph 7.1(a):

> Objective – the primary objective of the Airport Emergency Services (AES) is to save lives in the event of an aircraft accident/incident or fire at an airport. This will be accomplished by providing a fire-free escape route for the safe evacuation or rescue of passengers and crew. A secondary objective is to preserve the property involved by containing or extinguishing, where practical, any fire resulting from an aircraft accident or incident.
>
> (Exhibit 187)

This paragraph is found, unchanged, in the current edition of the A.I.P., except that the title Airport Emergency Services has been changed to Airport Crash Firefighting and Rescue Services (CFR). The statement in question is extracted from the Transport Canada Crash Firefighting and Rescue Standards, AK-12-03-001; Policy document: TP 3660. This Transport Canada document further states that:

> Specifically, the CFR will normally be the first to arrive at the scene of an aircraft emergency. Upon their arrival, action will be taken to prevent, control, or extinguish fire involving or adjacent to an aircraft for the purpose of providing fuselage integrity and an escape area for its occupants. Such efforts shall be under the direction of the senior CFR officer present.

> The CFR will participate, to the extent possible within their available resources, with the flight crew in the evacuation of passengers. If the flight crew are unable, for whatever reason, to open usable emergency exits, CFR personnel will, by whatever means necessary, force entry to the aircraft and provide assistance in the evacuation/rescue of the occupants.
>
> (Exhibit 243)

Mr Brian Boucher, an Air Canada pilot and representative of the Canadian Air Line Pilots Association (CALPA), a well-trained fire-fighter and fire professional and a trained specialist in aircraft fires, assisted this Commission with respect to fire-related issues. During his testimony, Mr Boucher was questioned about the roles of fire-fighting units in general and about the Dryden CFR unit in particular. While responding to a specific question about the use of handlines, Mr Boucher provided insight into the roles and priorities of fire services and fire-fighters. The relevant portion of his evidence pertinent to an assessment of the fire-fighting response by the Dryden CFR unit on March 10, 1989, and in particular whether handlines were brought to the site of the crash of the F-28 in a timely manner, was as follows:

> Q. All right. Given your background and given your experience in fighting fires, would you have – in that position that they were in, would you have taken a hand line into an aircraft immediately or attempted to?
>
> A. The role of the fire department, the role of the fire service is to save lives. The fire service has tactical priorities. The first priority is rescue. The second priority is fire control. Either you control the fire offensively or defensively. After you have taken care of that tactical priority, then you go into the final stage which is property conservation.
>
> When I talk rescue, we break rescue down into two areas, a primary search and a secondary search. Now, the primary search is to immediately try and rescue people that would be in immediate danger, to prevent further injury, and that's the key word there, to prevent further injury. In order to do that, especially when you have a fire burning, in order to prevent further injury from the people that you are trying to rescue and yourself, and the survivors, is no different than a structure fire. You have to take something to control the fire, something with you to help you to carry out this primary search. So it would be a mandate to take a hand line with you as soon as possible, as soon as you were able to take that hand line.
>
> It's no different than a structural fire. An airplane on the ground burns, as far as fire dynamics goes, the same as a building, a structure fire or a trailer fire that has life in it. The major difference with airplane fires is it has fuel on board. And

> as I have explained earlier, you have that problem with a fuel-fed fire, and what that does is gives you only a few minutes to do your job, to carry out a primary rescue, or at least try and control the fire in order to get up, get inside to do a primary rescue. After you have completed the primary rescue and if you can't get inside an airplane or a building, you always check the surrounding area of the incident that you have responded to.
>
> When that's been completed, you go into fire control and you put the fire out. And then, last, you go into property conservation and that's overhauling the airplane and making sure you put out all the spot fires and so you don't get any more damage by letting the fire continue to burn.
>
> If you cannot do a primary search, get inside, because when you arrive there, the cabin is totally involved, as we call it, fully involved. Then as soon as the fire is knocked down, you then do a secondary search. And when you do a secondary search, the possibility of survival is very remote.
>
> (Transcript, vol. 68, pp. 108–10)

CFR Response Areas

The CFR response areas delineated in the A.I.P. and Transport Canada CFR standards document AK-12-03-001 are generally followed in the Dryden Airport CFR Standard Operating Procedures manual. An insert page in this Dryden airport CFR manual titled: "Response to Aviation Emergencies Off-Airport," effective November 18, 1985, clearly requires that the Dryden CFR respond even to "off-airport" aircraft accidents:

> CFR personnel shall respond to aircraft accident/incidents off-airport in accordance with policies/procedures outlined in Transport standard AK-12-03-001 sec. (A) 3.01, 3.03, 3.04, 3.05, and the Dryden Municipal Airport Emergency Procedures Manual.
>
> (Exhibit 76)

Subsection 3.01 of the Transport Canada CFR Standards Manual sets out the responsibilities of a CFR unit as follows:

> The primary responsibility of the CFR shall be to respond to an aircraft accident/incident on the areas within the Critical Rescue and Firefighting Access Area (CRFAA) and airport boundary; the secondary responsibility shall be to respond to an aircraft accident/incident occurring beyond the CRFAA and airport boundary when it is considered that the crash site is reasonably accessible and a useful service can be rendered.
>
> (Exhibit 243)

It is noteworthy that the word "shall" is used in both the Dryden Airport CFR Standard Operating Procedures manual and in the Transport Canada CFR Standards AK-12-03-001 policy document to describe both the primary and secondary responsibility of the CFR.

Critical Rescue and Fire-fighting Access Area (CRFAA)

A CRFAA is defined in the Transport Canada Crash Firefighting and Rescue Standards AK 12-03-001 policy document as a rectangular area, 300 metres wide, centred on a runway, and extending 1000 metres past each end of the runway (see figure 9-1). The CRFAA is the area where the majority of aircraft accidents have historically occurred, and the boundaries of the CRFAA are not necessarily coincident with the airport boundary. The terrain conditions within the CRFAA are not taken into account in the definition.

Applying the criteria set out in the Dryden Airport CFR Standard Operating Procedures and in the Transport Canada CFR Standards document AK-12-03-001 policy document, the portion of the CRFAA at the west end of Dryden airport consisted of an area 300 metres wide, centred on runway 29, and extending 1000 metres west of the end of the runway.

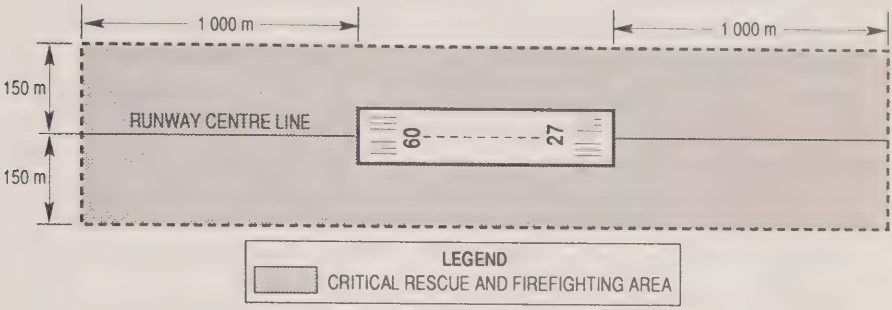
Inasmuch as flight 1363 began striking trees 127 metres to the west of the end of runway 29 before crashing and coming to a stop 962 metres to the west of the end of runway 29 at Dryden, almost in line with the runway centre line, I find that the crash occurred within the Dryden airport CRFAA.

The evidence is clear that the Dryden CFR unit never at any time conducted fire-fighting training within the CRFAA of the Dryden airport. The reason for this appears to lie, at least in part, in the lack of understanding by the Dryden CFR unit of the concept of the CRFAA, and in the failure by Transport Canada to define clearly the meaning of the CRFAA and to ensure that all CFR units understood their responsibilities with respect thereto.

During his testimony, Chief Parry discussed the responsibilities of the CFR unit at the Dryden airport. It was his opinion that the primary responsibility of the CFR unit was to perform crash, fire-fighting, and rescue operations on the airport. Chief Parry disagreed that part of the primary responsibility of the Dryden CFR unit was to respond to aircraft accidents beyond the airport boundary.

He also was of the view that the Dryden airport did not have a viable CRFAA because of the difficult terrain at the runway ends. The fact remains, however, that there was a CRFAA for the Dryden airport and that there were CFR access gates at both ends of the airport. The CFR

Figure 9-1 CRFAA



Source: Transport Canada, *A.I.P. Canada*

access gate at the west end of runway 29 led to a road that passed through the eastern portion of the CRFAA in which the crash occurred. This road provided direct access from the west end of runway 29 to McArthur Road.

As is pointed out elsewhere in this report, this access road, because of lack of winter maintenance, was not available to the CFR fire trucks that had hurriedly been driven to the west end of the runway immediately after the crash. These trucks then had to return from this point to the terminal area to get to public roads leading to the crash site, thus adding to the accident response time.

A reference contained in section 3.02 of Dryden Municipal Airport CFR Standard Operating Procedures manual to the Transport Canada CFR Standards AK-12-03-001 policy document implied that the CRFAA was part of the Dryden CFR unit's area of primary responsibility.

The Dryden Municipal Airport Emergency Procedures Manual (unapproved by Transport Canada at the time of the crash) states the following in section 3.02, in relation to the CFR response to an aircraft crash off-airport:

> 1. The primary responsibility of the CFR is to respond to aircraft accidents/incidents within the airport boundaries (CRFFAA[1]).
> 2. The Chief, CFR may dispatch CFR equipment and/or manpower to an aircraft accident/incident outside airport boundaries provided the site is reasonably accessible, a useful service can be rendered, and measures taken so the primary CFR responsibility is not jeopardized.
>
> (Exhibit 51)

1 Abbreviations of critical rescue and firefighting access area are seen, in documentation, as both CRFAA and CRFFAA.

From a reading of paragraph 1 above, it appears that the authors of the Dryden Municipal Airport Emergency Procedures Manual, by including, in brackets, the term (CRFAA) in paragraph 1, either regarded the airport boundary and the boundary of the CRFAA to be coincident or that the portion of the CRFAA that lay outside the airport fencing was to be considered as being inside the airport boundary, and therefore a CFR area of primary responsibility. The evidence shows, however, that this was not clearly understood by the Dryden CFR unit.

Transport Canada documents are not specific when discussing CFR response areas. The Transport Canada CFR Services Standards document AK-12-03-001 contains phrases that are not precise. In section 3.01 of the document, the phrase "beyond the CRFAA *and* airport boundary" is twice used, and in sections 3.02 and 3.03 the phrase "within the CRFAA *or* airport boundary" and "beyond the CRFAA *or* airport boundary" are used (emphasis added). There is more than one way to interpret the quoted phrases and this can lead to misunderstanding on the part of CFR personnel, as appears to have been the case at Dryden. Clearly, in directions about the response to aircraft crashes, there should be no ambiguity. Common sense would lead me to believe that Transport Canada would want CFR units to respond, to the best of their ability, to a crash in the entire area of a CRFAA, be it wholly inside, or partially outside, the airport boundary. Although I would interpret the provisions of AK-12-03-001 to mean in fact that a CFR unit should respond to an aircraft accident/incident that occurs even beyond the CRFAA or airport boundary, it is imperative that Transport Canada ensure that such intent be spelled out clearly in each airport's emergency plan and understood by each CFR unit.

Mr Larry O'Bray, the superintendent of CFR services, Transport Canada, Central Region, testified that fire-fighters should occasionally train in off-runway CRFAA areas and that, as most of the CRFAA area is off-runway, it is important that training with handlines be conducted in all areas of the CRFAA. He also testified that attention to training in the CRFAA and training with handlines had not been stressed or encouraged by Transport Canada. This observation is reinforced by the fact that Dryden airport training records indicate that the Dryden CFR unit there never trained off-airport and never trained for a crash inaccessible to the fire vehicles (as was the case in this accident), and requiring the use of extended handlines. Nor is there any indication in the evidence before me that Transport Canada has ever been concerned in this matter.

I agree with Mr O'Bray regarding the importance of CFR fire-fighters conducting reasonable and realistic handline training within the off-runway area of the CRFAA and not simply on the level, hard-packed airport property or hard-surface areas such as runways and taxiways. It

is important that fire-fighters be able to use handline equipment when fire-fighting vehicles cannot be driven to the fire.

The evidence, however, shows that any misunderstanding of the responsibility of a CFR unit to respond to an accident within the CRFAA had no bearing on the outcome of the March 10, 1989, accident, other than the fact that such lack of understanding may have influenced the absence of CFR training by the Dryden CFR unit within the CRFAA, especially with regard to the use of handlines.

Since there are areas on and off airports, but within the CRFAA, that may be inaccessible to fire-fighting vehicles, it is clearly up to Transport Canada to ensure that airport authorities, in conjunction with their respective CFR units, determine the most appropriate ways to deal with emergencies within each airport boundary and within the CRFAA, and to conduct appropriate training. Inasmuch as the secondary responsibility of CFR units is to provide a service outside the airport boundary and CRFAA, some planning and training in this respect should be carried out as well.

Dryden Airport CFR Unit on March 10, 1989

Fuelling Procedures at Dryden

The term "hot refuelling" refers to the procedure whereby an aircraft is refuelling while one, or more, of its engines is operating. Because the running engine is an ignition source and there is the possibility of fuel spilling, precautions are normally taken to ensure the safety of the passengers, crew, fuellers, aircraft, and other facilities.

Transport Canada, Airports and Properties Branch, Winnipeg, issued, on May 8, 1978, "for the attention of all concerned" a letter outlining the procedures for refuelling a Boeing 737 with one engine running. The following passage is quoted from the letter:

> <u>Procedures:</u>
>
> (a) This procedure will be permitted only when the APU of the aeroplane is unserviceable and the necessary ground power for an engine start is not available on the airport.
>
> (b) All passengers are to be off-loaded and cleared from the area during the refuelling period.
>
> (c) Pressure refuelling permitted to a maximum volume of ninety percent of each tank capacity of the Boeing 737 and at a fuelling pressure not to exceed 30 PSI.

(d) Normal static discharge precautions taken.

(e) Fuel quantity at wing refuelling station and in cockpit to be monitored throughout procedure.

(f) A responsible company employee to be positioned at nose of aircraft to observe refuelling operation while in direct radio communications with crew member or maintenance man in the cockpit qualified to handle power plant controls.

(g) An entrance door to be open providing a satisfactory evacuation route for any crew members or company servicing personnel on board.

(h) All available fire fighting equipment shall be located within operational distance of the aeroplane.

(i) The aircraft to be positioned the maximum distance from the air terminal or other structure consistent with fixed apron or cabinet refuelling capability. Where possible this separation should be not less than 250 feet from the public terminal or passenger waiting room.

(j) The Airport Manager or his representative shall be advised before the company initiates each such refuelling procedure.
(Exhibit 273)

The testimony of Transport Canada emergency services officers indicated that this directive relating to hot refuelling of the Boeing 737 aircraft had been circulated to all airport managers in Central Region where Boeing 737 aircraft operated, including Dryden. However, it had not been passed on to the Dryden CFR unit by the airport manager. The CFR fire-fighters at Dryden had no knowledge of the directive or its contents until after March 10, 1989, when it was shown to CFR crew chief, Mr Stanley Kruger, by Mr Jack Nicholson, Transport Canada, Winnipeg.

On March 10, 1989, because the APU on C-FONF could not be used by the flight crew to start the engines, and there was no ground-start capability for the F-28 at Dryden, it was necessary to hot refuel the aircraft (see also the description in chapter 5, Events and Circumstances Preceding Takeoff). The aircraft was parked in the normal parking area with the centre line of the aircraft about 90 feet from the Dryden terminal. At approximately 11:40 a.m., after the aircraft had been parked and the pilots had discussed refuelling with Mr Vaughan Cochrane, the Dryden Flight Centre representative, Mr Cochrane called the fire hall and asked Mr Kruger to have the fire-fighters hurry to the terminal area

since the F-28 was to be refuelled while one of its main engines was running. Mr Kruger relayed the information to his partner, fire-fighter Gary Rivard, and they drove two fire-fighting vehicles, Mr Kruger in Red 1 and Mr Rivard in Red 2, to the terminal area. According to Mr Kruger, the F-28 refuelling was underway when they arrived at the terminal. The fire vehicles were parked 100 to 125 feet in front of the aircraft facing downwind in an easterly direction, with Red 2 covering the refuelling operation and Red 1 to the right of Red 2 covering the aircraft exits. Once the hot refuelling was completed, Red 1 returned to the fire hall while Red 2 remained in position until C-FONF taxied away from the terminal.

During testimony, Mr Kruger stated that he was aware that hot refuelling meant refuelling with an engine running, but he had not received formal instructions on procedures to be followed. He did, however, know that he was to cover the aircraft during a hot refuelling in case of an emergency. Some time after March 10, 1989, Mr Nicholson provided a copy of the May 8, 1978, letter to Mr Kruger.

Mr Jeffrey Hamilton, an emergency services officer, Transport Canada, Airports Authority Group, Central Region, an experienced commercial bush pilot and a qualified CFR fire-fighter and fire officer, testified that the Dryden CFR personnel did not follow the correct procedures for hot refuelling as set out in the May 8, 1978, letter. Mr Hamilton also testified that, if hot refuelling is taking place and the correct procedures are not being followed by the flight crew and the fuelling agent, the CFR fire-fighters should insist, on the spot, that refuelling immediately cease and the correct procedures be complied with.

Many of the hot refuelling procedures specified in the May 8, 1978, letter were not followed. Because none of the Dryden CFR crew were aware of the correct procedures, the appropriate action was not taken by either Mr Kruger or Mr Rivard. Mr Kruger observed that the passengers stayed on the aircraft during the hot refuelling. Even if Mr Kruger was not aware that hot refuelling with passengers on board was not allowed, he was aware that the hot refuelling was taking place too close to the terminal building. During testimony, he stated it was his opinion that the aircraft was parked too close to the terminal and that, if anything happened to the aircraft, the terminal would probably have been affected. It is my view that Mr Kruger, as crew chief, should have at least stopped the fuelling because of the proximity of the aircraft to the terminal building. Chief Parry, who was in the vicinity of the aircraft at that time, was neither aware that a hot refuelling was taking place nor indeed aware of what the term meant.

As the evidence of the hot refuelling at Dryden came to my attention early in this Inquiry, I made an interim recommendation on an urgent basis to the minister of transport at the commencement of the hearings

in Dryden, later formalized in my first *Interim Report* as Interim Recommendation No. 1, as follows:

> The Department of Transport prohibit the refuelling of an aircraft with an engine operating when passengers are on board, boarding, or deplaning.

Transport Canada subsequently issued a notice to all air carriers requesting voluntary compliance with the interim recommendation until the necessary legislation was drafted and passed. I am advised by representatives of the Department of Transport that such legislation will be in place by the end of 1991.

When the refuelling hose was disconnected from C-FONF after the hot refuelling at the Dryden airport was completed, about 5 litres of fuel poured out of the aircraft fuelling manifold onto the tarmac. The fuel spill was observed by the three CFR staff who were in the vicinity of the aircraft. Mr Kruger discussed its cleanup with the refueller, Mr Cochrane, and they agreed that, because the spill did not pose a significant threat, it would be cleaned up after C-FONF had departed the area. Once the aircraft taxied away, Mr Rivard used the main turret water gun on Red 2 to wash the fuel away. He estimated that 200 to 300 gallons of Red 2's approximately 1000-gallon water capacity was used.

Mr Hamilton, when asked how a CFR fire-fighter should have handled the fuel spill, stated in testimony that, a "fuel spill of that size could have been handled with absorbent material, either a speedy dry or an aquasorb or even sand could have been spread on the spill and cleaned up as opposed to using the resources from the truck" (Transcript, vol. 34, p. 4). Both Mr Kruger and Chief Parry testified that using water from the CFR vehicles to clean up a small fuel spill was a misuse of a valuable resource and that the procedures had been changed regarding cleanup of such spills. I agree with Mr Hamilton that absorbent material, not the CFR fire-fighting equipment, should be used to handle small fuel spills. The fire trucks should have been available with full water tanks in case of an emergency during aircraft operations. If, however, a fuel spill is sufficiently large, it should be cleaned up before the aircraft's engines are started.

The Dryden airport is subsidized by Transport Canada and is subject to operating guidelines issued by Transport Canada, including the guidelines regarding the fuelling of aircraft. The Dryden Flight Centre, which is the airport handling agent for ESSO Petroleum Canada, must, as well as following Transport Canada guidelines, follow the guidelines or instructions issued by ESSO for the handling of ESSO products.

Transport Canada policy documents AK-66-06-400, Aviation Fuelling Manual: Fuel Storage, Handling and Dispensing; AK-12-06-004, Airport Crash, Firefighting, and Training Manual, and TP 1297 AK-71-20,

Manual of Standard of Procedures for Aircraft Fuel Servicing, set out the standards and guidelines relating to aircraft fuelling on Transport Canada–operated and Transport Canada–subsidized airports.

Transport Canada, as one the largest operators of airports in North America, created the documents noted above based on its experience in aircraft fuel handling and knowledge of previous fuelling-related accidents. The destruction of an Air Canada DC-8 aircraft in Toronto, Ontario, on June 21, 1973, to which I referred in my first *Interim Report*, is one example of such an occurrence. This aircraft caught fire during refuelling; however, the source of ignition was never determined. The boarding of passengers on the Air Canada DC-8 had just been approved but, fortunately, had not yet commenced when the first explosion took place.

ESSO Petroleum Canada's Aviation Operations Standards Manual, which describes in detail how to handle aviation fuels and other ESSO products safely, is issued to all ESSO agents, including the Dryden Flight Centre.

Transport Canada policy document AK-66-06-400 outlines the provisions relating to bonding and grounding an aircraft during fuelling to prevent the buildup of static electricity that could lead to static discharge and ignition of fuel vapours. Provisions in the document require that the aircraft and the refuelling vehicle each be grounded, the aircraft and the refuelling vehicle be bonded to each other, and the fuel nozzle be bonded to the aircraft.

Mr Jerry Fillier, an employee of Dryden Flight Centre, initially started to hook up the fuel truck to C-FONF but was sent by Mr Cochrane to refuel another aircraft at the fuel cabinets. Mr Cochrane then completed the hook-up and hot refuelling of C-FONF. During his testimony, Mr Fillier stated that he bonded the truck to the aircraft but did nothing else regarding the refuelling of C-FONF. He knew the procedures for proper bonding but did not know that the aircraft should have been grounded. It was not determined conclusively during the testimony of Mr Cochrane whether he completed the required bonding and grounding before he started to refuel the aircraft.

Transport Canada policy document AK-12-06-004 states at page 51 that:

> With Type B jet fuel, due to its relatively low vapour pressure, the vapour-air mixture above the liquid surface, under normal temperature and pressure conditions, will often be within flammability range. This means that ignition of Type B vapours either inside or outside a tank may cause violent combustion within the confined

> space if the flame enters. Type A jet fuels do not give off flammable vapours in ignitable amounts unless the fuel temperature is above 35°C.
>
> (Exhibit 244)

C-FONF was refuelled at Dryden with Jet B fuel, and the temperature during the hot refuelling was 1°C, a temperature within the fuel's flammability range.

On all refuelling vehicles, there is a dead-man switch that normally must be held continuously by the refueller in its "on" position to allow fuel to flow. This safety feature will cause refuelling to stop the moment the switch is released. The safety feature of the switch can be bypassed by, for example, taping the switch "on" or by using a switch override.

The ESSO Aviation Operations Standards Manual states at section 020-004, page 18, as follows:

> Deadman control devices must be installed on all underwing fuelling vehicles.
>
> Unless prohibited by local regulations, these devices may have an over-ride which must be sealed in the normal position. This over-ride can be used to complete a fueling in case of a faulty deadman.
>
> Corrective action must be taken to repair the deadman immediately after fueling is completed.
>
> (Exhibit 173)

Transport Canada policy document AK-66-06-400, subparagraph 8.04 at page 8, states in part: "Self-closing nozzles or deadman controls shall not be blocked open or bypassed" (Exhibit 270). Mr Cochrane testified that it was normal at Dryden to override the dead-man switch when refuelling, and, in this instance, he caused the dead-man switch to be bypassed.

The ESSO manual states in its introduction to section AOSM 202-007, page 1: "Fueling of an aircraft with one propulsion engine running is a *non-routine, emergency operation* and as such requires very strict safety precautions, in addition to those given elsewhere ... [emphasis added]" (Exhibit 173).

The ESSO manual also states that, when hot refuelling is to take place, all passengers must deplane, the customer must sign an indemnification release statement, a representative of the customer must supervise the refuelling, the operation must be reviewed beforehand by the customer and the agent, the aircraft must be positioned at least 150 feet from any building or aircraft, and all persons not directly needed for the refuelling must be at least 150 feet away. Mr Cochrane, although a representative and agent of ESSO, was not aware of these provisions and did not take any steps to ensure that they were met.

The evidence shows that there was nothing in any manuals normally used by Air Ontario F-28 pilots regarding hot refuelling, a serious omission. However, the Air Ontario Flight Attendant Manual, Section 2.31, Item 12, states as follows:

> When refuelling is required with one engine running, all passengers are to be off-loaded and cleared from the area during the refuelling period. Flight Attendants should also leave the aircraft.
>
> (Exhibit 137)

It is my view that, during the hot refuelling of aircraft C-FONF, the Dryden Flight Centre refuellers used unsafe procedures in that they did not follow any of the special precautions outlined in the ESSO manual. The failure to use the dead-man control device, the possible inadequate grounding, the fact that there were passengers and crew on board the aircraft, and the fact that the aircraft was closer to the terminal and other persons and equipment than allowed are made more dangerous by the fact that Jet B fuel, which is more volatile than Jet A fuel, was being pumped into the aircraft. The hot refuelling was completed in disregard of proven safety procedures, either because the proper procedures were not known or, if the procedures were known, the dangers involved were not appreciated.

It is also my view that the pilots of C-FONF should have been aware that extra precaution was required when hot refuelling with passengers on board.

The CFR fire-fighters were in the vicinity and monitored the hot refuelling, and they, as well, are equally responsible for ensuring that refuelling be as safe as it can be. As professionals, they should, because of their training and knowledge, be able to spot unsafe practices, and they should intervene to preclude an obvious fire hazard. The evidence is clear that the CFR unit did not intervene in any way with the refuelling other than to clean up the small fuel spill.

It is obvious from all the evidence that the flight crew were anxious to depart Dryden as soon as possible, and I am left with the impression that the fuelling agent, who was also the ground-handling agent for Air Ontario, was in a hurry to fuel C-FONF at Dryden. By so doing, he ignored many precautions that are in place to promote safe fuelling operations.

As a result of the evidence and testimony that came before me during the course of the hearings, Transport Canada, on March 22, 1990, issued an AK directive by way of a memorandum to all airport managers of Transport Canada–owned and operated airports and Transport Canada–subsidized airports dealing with airport fuelling procedures. The memorandum is as follows:

> The purpose of this memo is to reconfirm that the TC fuelling safety procedures covered in TP 2231 (AK-66-06-400) are still in force and shall be followed at Transport Canada owned and operated airports, and extended to subsidized airports in line with ADM memo of February 15, 1990. You are asked to take immediately the necessary steps to implement TP 2231 (AK-66-06-400) with emphasis on the following sections:
>
> <u>Section 4.05</u>
> The Airport Manager *shall* maintain a separate file for each fuel company or handling agency, which will provide a record of all inspections, document verification, and violations of the policies and standards outlined herein.
>
> <u>Section 4.06</u>
> The Airport Manager shall recommend that an agreement, lease, or other contract document be terminated or not renewed, <u>if the training</u> record of any employee engaged in the handling of fuel or fuel vehicles or equipment <u>is not provided</u> when requested and/or if standards or <u>safety and security requirements are not met</u>.
>
> <u>Section 4.07</u>
> The Airport Manager shall advise the fuel system operator, the airport management committee, or the airlines and the fuelling committee, if established, of any deficiencies in the fuelling area.
>
> Strict adherence to these standards are compulsory, and any deviation from them must be requested from AK – Ottawa.
> In order to ensure compliance from coast to coast, I requested that AKOB[2] personnel conduct "spot checks" at airports regardless of their size. This is a very important safety matter, and I trust that you will do your utmost to ensure its full implementation.

I commend the action taken by Transport Canada both in reaffirming that Transport Canada Fuelling Safety Procedures covered in policy document AK-66-06-400 shall continue to be in force, and in extending the mandatory fuelling safety practices and procedures to subsidized airports in Canada. I also agree with Transport Canada's decision to have its personnel conduct spot checks at airports to ensure that knowledge, training, and standards of safety are met regarding fuelling procedures. However, I see no reason why CFR personnel, upon receiving proper training regarding aviation fuels and fuelling pro-

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[2] AKOB is the designation for personnel in Transport Canada Airports Safety Services, Ottawa.

cedures, cannot be used to monitor fuelling procedures on a continuing basis and act as Transport Canada's representatives in ensuring compliance with the standards and procedures. Since the airport CFR unit, as an arm of Transport Canada's airport authority, has a real interest in having fuelling practices and procedures conducted in a safe manner, it seems only logical that they be mandated to ensure that standards are maintained.

Crash Gate Access Roads

At the Dryden airport, there are roads at either end of runway 11/29 leading to gates built into the airport perimeter fences in line with the runway. The roads and gates are to provide the CFR fire vehicles immediate access off the runway ends into the critical rescue and fire-fighting access area (CRFAA) beyond the airport proper in the event of an aircraft crash. On March 10, 1989, the access road to and beyond the crash gate at the west end of runway 29 could not be used by the fire vehicles because it had not been cleared of snow. During testimony, Crew Chief Kruger stated that he was of the opinion that the access roads should be kept open and accessible, and that he had communicated this view to both Chief Parry and Mr Louttit, the airport manager, on a number of occasions prior to March 10, 1989. Mr Kruger testified that the access road could have been kept open easily with the airport grader or front-end loader and that "a lot of minutes could have been saved" in reaching the crash site if this had been done (Transcript, vol. 26, p. 159). After the crash of C-FONF, Mr Kruger and Mr Garry Galvin, the other Dryden CFR crew chief, wrote a summary of observations and suggestions by the Dryden CFR crew. The summary was dated March 13, 1989, and stated in part as follows:

> Better maintain access roads to runway, road from firehall to the runway should be kept sanded on a priority basis in winter months. Access roads at the end of the runway at each end should be kept open in winter months.
>
> (Exhibit 186)

Mr Arthur Bourre has been an employee of the Dryden airport for approximately 10 years and is an experienced meteorological observer and equipment operator. During his testimony, he agreed with Mr Kruger that the access roads should be kept clear of snow, that the CFR crews had requested the same of Dryden airport management, and that it would not be difficult to keep them open using airport equipment. Mr Hamilton, a Transport Canada emergency services officer, agreed that the access roads should be kept clear.

Although Transport Canada's policy manual AK-72-40-200, Manual of Snow Removal and Ice Control Operational Requirements, does not clearly state policy on crash roads, it does establish priorities for snow and ice removal to keep an airport operating. This document establishes three levels of priority for areas to be cleared during and after a snowstorm. The airside priority I area requires, among other things, that access roads from the fire hall to the active runway be cleared at all times. The airside priority III area sets out the following requirements in section 4.02 (a)(iii):

> Priority III Area
>
> The Airside Priority III Area includes those surfaces that are cleared after a snowstorm. They are:
>
> (1) all other runways and taxiways;
> (2) airside service roads;
> (3) runway, taxiway shoulder areas;
> (4) pre-threshold areas;
> (5) glide path sites;
> (6) remaining airside areas required to permit full operational use of the airport.

While the priority III area does not expressly include crash gate access roads at runway ends, I interpret the statement in subparagraph (6), "remaining airside areas required to permit full operational use of the airport," to be broad enough to include crash gate access roads at the runway ends.

I heard no reasonable explanation as to why the management of the Dryden airport did not keep the crash gate access roads open during the winter. I find this particularly disconcerting in view of the fact that a Dryden CFR fire-fighter had repeatedly requested of airport management that this be done. I find that both the airport manager, Mr Louttit, and Chief Parry had a duty to ensure that the crash gate access roads were kept open and that they did not discharge that duty.

Transport Canada, Central Region, Emergency Services Organization, did not identify this problem. Its inattention to this area appears, in large part, to have been attributable to the lack of adequate resources, to inappropriate lines of authority, and to the lack of adequate control by Transport Canada over the Dryden airport and the CFR unit.

As a result of the evidence put before this Commission with regard to the Dryden airport crash gate access roads not being maintained during the winter months, the director-general airports operations, Transport Canada, on March 23, 1990, issued the following directive:

SNOW REMOVAL – EMERGENCY ACCESS ROADS AND GATES

> During the recent Commission of Inquiry hearings concerning the Crash Fire Rescue (CFR) response to the Air Ontario crash at Dryden, Ontario, there was considerable criticism regarding the fact that emergency access roads at the ends of the active runway had not been maintained during the winter months.
>
> Pending an amendment to the "Snow Removal and Ice Control Standard," we would ask that emergency access roads and crash gates at each end of every active runway are cleared of snow as part of the after storm clean-up. In addition, these instructions extend to subsidized airports in line with AK's direction of February 15, 1990.

I endorse the action of Transport Canada in instructing airport managers to ensure that emergency access roads and crash gates at each end of every active runway are clear of snow as part of the after–storm cleanup. I also endorse the amendment to policy document AK-72-40-200 to ensure that access roads and crash gates are more clearly defined in the priority III area subsection of the document.

Activities of CFR Fire-fighters

The evidence leaves no doubt whatsoever that the CFR personnel who attended at the scene of the crash allowed themselves to become diverted from their responsibility to take action to prevent, control, or extinguish the fire involving or adjacent to the aircraft, as set out in Transport policy document AK-12-03-001. Instead, they gave in to human instinct and assisted the survivors who were already outside the aircraft.

I will not review in detail the actions and the efforts of crew chief Kruger and fire-fighter Rivard, the first CFR members to arrive at the scene, in assisting passengers who had extricated themselves from the flaming aircraft wreckage. The passengers' recollections are discussed elsewhere in this report. While it is not difficult to understand Mr Kruger's and Mr Rivard's instincts of human compassion which caused them to become absorbed in assisting the survivors, their actions demonstrate the need for adequate training of CFR crews about their primary responsibility at an aircraft accident site. At the same time, I commend Mr Kruger for making his way immediately to the crash site, assessing the situation, and directing much of the rescue activity.

I will comment later on the actions of Chief Parry as on-site coordinator. My comments and observations now will be directed at the actions of Chief Parry, crew chief Kruger, and fire-fighter Rivard in their capacity as professional CFR personnel responding to the crash of C-FONF.

The CFR unit acted in a timely manner in initially responding to the crash, except that Mr Rivard arrived at the crash site approximately 30 minutes after the arrival of Chief Parry and Mr Kruger because he got stuck in a snow bank at the airport, and because he stopped to top up Red 2 with water.

Paragraph 3.01 of the draft Dryden Emergency Procedures Manual deals with aircraft crashes off-airport and states inter alia, that: "Aircraft accidents/incidents outside the airport boundaries are the responsibility of the O.P.P. and the site will be under their command" (Exhibit 71). Paragraph 3.02 in part states: "The Chief ... [in this case, Chief Parry] may dispatch AES [Airport Emergency Services] equipment and/or manpower to an aircraft accident/incident outside airport boundaries provided the site is reasonably accessible, a useful service can be rendered, and measures taken so the primary AES responsibility is not jeopardized."

At the time, Chief Parry did not consider the ramifications of leaving the airport unattended, nor did he stop to consider the issues of jurisdiction or responsibility; his perceived requirement was to get himself, his fire-fighters, and his fire-fighting equipment to the crash site as quickly as possible. During the hearings, Chief Parry testified that his primary responsibility was the airport, that he had left it unattended, and that he would not have been able to respond to an emergency at the airport. Chief Parry explained his actions in responding to the crash by stating the following in testimony: "considering the weather conditions, and the fact that the primary aircraft was down, I did not anticipate any other aircraft of an F-28 or primary aircraft size at the airport at that time" (Transcript, vol. 6, pp. 272–73).

In my view, Chief Parry properly exercised his discretion in responding to the crash. Clearly there was a possibility that the CFR fire-fighters could render a useful service. Although the evidence demonstrated that Chief Parry lacked a full understanding of the scope of his responsibilities and duties and that his views regarding the CRFAA were questionable, these factors did not affect the initial CFR response.

The airport manager was immediately involved in the response to the crash and was aware that, once the CFR vehicles left the airport, there was no CFR service available to respond to further emergencies at the airport. He was therefore in the best position to notify all potential users and operators of the lack of availability of CFR services. It was not until 3:46 p.m. EST, however, that a notice to airmen (NOTAM) was issued by Kenora Flight Services stating that CFR services were not available at the Dryden airport. Another NOTAM was issued at 4:30 p.m. EST indicating that CFR services were again available.

Initial Response by CFR Unit to the Crash

Each of the three Dryden CFR staff who responded to the crash of C-FONF committed a number of errors that, given the evidence as to their inadequate training, are understandable Each error or mistake, by itself, may not have been significant in the overall response; however, in assessing the collective errors of these persons, I am led to question the level of training and knowledge of the personnel of this CFR unit. Accordingly, I will deal with the activities of the each of these persons.

Fire-fighter Rivard, an experienced truck operator and previously a part-time maintenance employee for the Dryden airport, had been a fire-fighter for a few months prior to March 10, 1989, and on that day was operating vehicle Red 2. In responding to the crash, Mr Rivard, in Red 2, and Chief Parry, in Red 3, drove on to runway 11/29 and proceeded quickly to the west end of the runway. The vehicles were not able to use the crash gate access road at the end of runway 29 to reach the public roads that led to the crash site, so both vehicles turned around and proceeded back towards taxiway Alpha and the service road. As Mr Rivard had depleted some of the water from Red 2 in washing down the fuel spill, he asked Chief Parry if he should refill the truck. Chief Parry instructed Mr Rivard to top up Red 2 before proceeding to the crash site.

Chief Parry exited the runway at taxiway Alpha, and Mr Rivard proceeded east to the service road to fill up Red 2 at the fire station. Mr Rivard estimates that he was travelling at approximately 40 mph while proceeding along the runway and slowed to approximately 25 mph to negotiate the turn onto the service road. The service road, while cleared, was snow packed and not sanded. On entering the service road, Mr Rivard lost control of the vehicle, and it slid into a snow bank. Airport maintenance employee Christopher Pike, using a front-end loader, pulled Red 2 from the snow bank, and Mr Rivard proceeded to replenish Red 2 with an estimated 200 to 300 gallons of water. He then proceeded to the crash site, arriving at the junction of McArthur and Middle Marker roads at 12:43 p.m. Approximately 30 minutes had elapsed between the time that Mr Rivard got stuck and the time he arrived at the crash site.

Crew chief Kruger, in vehicle Red 1, returned to the fire hall after monitoring the refuelling and observing C-FONF take off. Immediately on his arrival at the fire hall, he received a radio call from Chief Parry asking him to "get back out here" (Transcript, vol. 26, p. 109). Mr Kruger drove Red 1 back onto the runway and proceeded westbound. On seeing Red 2 and Red 3 coming towards him, Mr Kruger turned around and waited for Red 2 and Red 3 to catch up and lead the way. Mr Kruger followed Chief Parry off the airport property and to the crash site.

En route to the crash site, Chief Parry communicated by radio with the Town of Dryden as follows:

> This is Airport Red 3 we suspect we have an F-28 jet down approximately 3 or 4 miles west of the runway, please activate the mutual aid and emergency plan.
>
> (Exhibit 1282, p. 2)

Chief Parry parked Red 3 at the intersection of McArthur Road and Middle Marker Road, unlocked the gate to Middle Marker Road, and signalled Mr Kruger to go down this road the crash site. Chief Parry and Mr Kruger arrived at the intersection at approximately 12:18 p.m.

Fire Chief Parry

Chief Parry stated that, based on his experience with the exercises he had been involved with and the location of the crash site, he made the decision to stay at the intersection and establish a command post. He believed he would be most effective in directing arriving agencies where to go. This decision is not inconsistent with the CFR and other emergency training with which Chief Parry had been involved, and had been reinforced by Transport Canada officials who oversaw or reported on the training. All such training, however, had been conducted on the airport.

Chief Parry remained at the intersection, acting, in his view, as overall coordinator. Chief Parry's jurisdiction was never challenged by other responsible persons, and he voluntarily relinquished command to the Ontario Provincial Police (OPP) at mid afternoon on March 10.

Because of its location in Wainwright Township, the crash site came under the overall command of the OPP, and the fire-fighting responsibility came under the purview of the Unorganized Territories of Ontario (UT of O) Fire Department under the direction of Fire Chief Roger Nordlund.

During his testimony, Chief Parry agreed that the control of the fire-fighting effort should have been under the UT of O Fire Department, and that the overall responsibility in the area should have rested with the OPP. When asked to explain in what context or under what jurisdiction he established his command post, Chief Parry replied as follows:

> A. Simply that it was an aircraft incident and we were the first there.
>
> (Transcript, vol. 6, p. 269)

It appears to me that the overlapping jurisdictions in place at the crash scene on March 10, 1989, caused confusion and uncertainty as to the respective roles of those involved. This is an area in need of clarification,

as previously was discussed in chapter 8, Dryden Area Response. Chief Parry did not go to the crash site until approximately 3:30 p.m., some 3 hours and 20 minutes after the crash occurred, when he toured the site with Staff Sergeant D.O. Munn of the OPP. Chief Parry estimated that he was there for 10 to 20 minutes, long enough to ensure that there was no further need for the CFR unit and that he could do "an official turnover to the OPP" (Transcript, vol. 6, p. 267). It was not until later that he realized an official turnover was not required.

Crew Chief Kruger

After parking Red 1 on Middle Marker Road, Mr Kruger took a portable, two-way, two-channel FM radio and a first aid kit weighing approximately 25 pounds and walked into the site. It was Mr Kruger's intention to proceed to the crash site and assess the accident. Two civilians, Craig Brown and Brett Morry of Terraquest Ltd, who were the first persons to arrive at Middle Marker Road after the crash, had already walked through the deep snow to the crash site, and Mr Kruger followed the path they had made, catching up to them as they neared the crash site. Mr Kruger stated he could hear the fire, small explosions, and the sound of flames making an echoing noise in the bush.

As he neared the crash site, Mr Kruger met about 20 surviving passengers who presented a scene that was "hard to describe and put into words." The survivors were, in his words, "in various states of emotional distress, underdressed, and all of them coming towards me at the same time" (Transcript, vol. 26, p. 130). Mr Kruger gave them directions on how to get to Middle Marker Road and to the intersection. From his observations when he arrived at the crash site, Mr Kruger formed the opinion that there were no survivors in that aircraft.

By the time Mr Kruger arrived at the aircraft, all passengers who were to survive the accident, except two, had exited the aircraft either on their own or with the help of others. Two remaining survivors, Mr Uwe Teubert and Mr Michael Kliewer, were discovered at approximately 1:00 p.m. trapped under the left side of the aircraft. Under the direction and with the assistance of doctors Gregory Martin and Alan Hamilton, rescuers removed Mr Teubert and Mr Kliewer from the wreckage by approximately 1:10 p.m. Mr Kliewer was badly injured and incapacitated. They were both attended to by the doctors, taken out to the road on stretchers, and transported by ambulance to the Dryden hospital at approximately 1:45 p.m. Mr Kliewer died in hospital as a result of his injuries.

All other surviving passengers either made their own way out to Middle Marker Road or were assisted by other survivors, by Mr Kruger and Mr Rivard, by various UT of O and Town of Dryden fire-fighters,

by OPP officers, by numerous civilians, and by medical personnel from the Dryden hospital.

Mr Kruger stated that on arriving at the aircraft site, he observed many fires around the edge of the aircraft and that the aircraft itself was burning. He inspected the right-hand side up to the nose area of the aircraft, but did not proceed around the left side of the aircraft prior to the rescue of the trapped individuals. After inspecting the right-hand side, Mr Kruger decided to go back with the remaining survivors and wait until he got help with fire-fighting apparatus.

During his testimony, Mr Kruger stated that he recognized several individuals who arrived on the scene shortly after he did. From that fact alone, he knew that the disaster plan had been activated and that there would be other fire departments responding in short order.

Mr Kruger testified that after arriving at the crash site, he called Chief Parry on channel 1 of the hand-held radio, which he stated was "our airport operating frequency for our fire department," and provided him with a quick assessment of the accident (Transcript, vol. 26, p. 125). It was Mr Kruger's opinion that channel 1 was the frequency on which he would communicate with Chief Parry. Mr Kruger further stated that he advised Chief Parry that the crash site was about 150 yards from Middle Marker Road, that there were at least 20 survivors, that "there was an awful lot of the aircraft that was burning that could be saved and to get the handlines in as quick as possible" (Transcript, vol. 26, p. 136). Mr Kruger also testified that he told Chief Parry to send in men and equipment. In Mr Kruger's view, "men and equipment" was a self-explanatory statement meaning "firefighting apparatus" (p. 136). Red 1 could not be used as a fire-fighting vehicle because its handline was only 150 feet long and would not reach the accident site from the nearest point at which it could park.

Chief Parry agreed during testimony that Mr Kruger contacted him early on when he first went into the crash site and provided him with an estimate that it was 150 yards from the crash site to Middle Marker Road. It was Mr Rivard's testimony that he heard Mr Kruger make the request for handlines, stretcher boards, and men about three times and that Chief Parry was not answering Mr Kruger's calls. Mr Rivard stated that on two occasions, once while he was refilling Red 2 with water and again while he was driving to the crash site, he answered Mr Kruger's calls on his own radio but did not receive a reply. Mr Rivard stated that Mr Kruger's requests were made on channel 1, the CFR unit's emergency channel.

Mr Kruger testified that his call for handlines shortly after he got into the woods was acknowledged by Chief Parry. Since the tape recording of the fire channel at Dryden dispatch shows that Chief Parry began operating on the mutual aid channel before he arrived at the scene, any

such conversation and acknowledgement would have to appear on the same tape recording, unless Chief Parry had switched momentarily to channel 1. At 1:04 p.m. airport control radioed Red 3 (Chief Parry) that Red 1 had been talking to Kenora on VHF frequency 122.6. Chief Parry replied that he had lost contact with Red 1 and had sent a Dryden fire-fighter with a radio to try to re-establish contact. The first tape-recorded transmission from Red 1 occurs at 1:10 p.m., on channel 2, the mutual aid channel. This transmission was a request from Red 1 for handlines, which was acknowledged by Chief Parry. The evidence shows that, subsequent to his initial radio contact with Chief Parry, shortly after arriving at the crash site, Mr Kruger transmitted other information by radio, but these messages did not get to Chief Parry, probably because Chief Parry was then on the mutual aid frequency.

Fire-fighter Rivard, Mr Kruger's partner, also stayed on channel 1. In the minutes ofthe staff debriefing, held at the airport on March 14, the following recommendation appears:

> A better procedure is needed for CFR to know when to change from the CFR frequency to the Mutual Aid frequency on the FM radios.
>
> (Exhibit 37(e))

It would appear from all of the evidence that, after Mr Kruger's initial radio contact with Chief Parry after reaching the crash site, there was no further two-way radio communication between them until about 1:10 p.m. I conclude that Mr Kruger did not change his radio from channel 1, the CFR channel, to channel 2, the mutual aid channel, as Chief Parry had done. In his testimony, Mr Kruger discussed why he did not switch channels:

> Q. Did you have both channel 1 and channel 2 on your portable radio?
> A. Yes, I did.
> Q. Did you attempt to raise the Chief on channel 2?
> A. Not until some time later.
> Q. And why is it that you didn't think of switching to channel 2 when you didn't get a response on channel 1?
> A. I can't give you a definite answer on that. I think I was so caught up with the activity it – it did take some time. I had contacted my partner on the firefighting frequency. It never occurred to me, for any reason, that I should not be able to raise the Fire Chief on that channel.
>
> (Transcript, vol. 27, p. 63)

It would seem that the establishment of communications between Chief Parry and Mr Kruger would be a priority for both of them given their tasks as on-scene commander and fire-fighter. One radio call on the

other channel by either Mr Kruger or Chief Parry would have accomplished this linkage.

Mr Kruger spent the duration of his time at the crash site attending to surviving passengers and directing arriving individuals to various duties. On his immediate arrival, Mr Kruger gave his fire-fighter's coat to flight attendant Sonia Hartwick who was carrying an infant child, thereby negating his effectiveness as a fire-fighter. Mr Kruger became involved in assisting and carrying stretcher patients as "there was no surplus of help, rescuers, at the time" (Transcript, vol. 26, p. 149). On the arrival of Mr Rivard, Mr Kruger instructed him to grab the power saw out of Red 1 and brush out a trail to allow the stretchers to be carried out to Middle Marker Road. Mr Kruger then became involved in a ground search team that checked the flight path for passengers who may have been thrown from the aircraft.

Although all his actions were commendable, Mr Kruger became so involved in assisting the injured passengers that he forgot that, as the first professional fire-fighter at the scene, he should have focused his attention on fighting the aircraft fire, on the possibility of assisting trapped passengers, and on the preservation of evidence.

Fire-fighter Rivard

Mr Gary Rivard, on his arrival in Red 2 at the intersection of McArthur and Middle Marker roads at 12:43 p.m., was signalled by Chief Parry to drive down Middle Marker Road. On driving towards the site, Mr Rivard realized that an ambulance, which had been allowed access down Middle Marker Road by the OPP and was parked behind Red 1, would be blocked by Red 2. Mr Rivard parked behind the ambulance and assisted Mr Harold Rabb, a Dryden ambulance driver, in getting two surviving passengers into Red 2. Mr Rivard then backed Red 2 out of the intersection to allow the ambulance to exit. As he was crossing McArthur Road at the intersection, there was a loss of air pressure from the air system of Red 2 that caused its brakes to apply automatically and the engine throttle to fail to idle power. The loss of air had been a recurring problem on Red 2. Mr Rivard, leaving the vehicle's engine running, assisted the survivors who were riding in Red 2 into other vehicles located on McArthur Road. Then, with the aid of a Dryden airport maintenance worker, Mr Christopher Pike, he overrode the failed engine throttle and locked brakes and moved Red 2 out of the way of the intersection. He parked Red 2 on the side of McArthur Road where it remained for the balance of the afternoon. Mr Rivard then made his way through the bush to the aircraft crash site.

While Mr Rivard admitted during testimony that he could, with the assistance of Mr Pike, have moved Red 2 back down Middle Marker Road close to the crash site, and, thereafter, with the assistance of

civilian rescuers, run a handline into the wreckage, he had no explanation why he did not do so. Nor did he check with Chief Parry to see whether he had heard the urgent requests for handlines made by Mr Kruger on channel 1. It strikes me that a properly trained fire-fighter, hearing no response to such important calls to the fire chief, would have done no less.

On his way in to the crash site, Mr Rivard came across rescuers struggling with passengers on stretchers. He assisted them and became involved with others in carrying three individuals on stretchers to Middle Marker Road. After helping with three stretchers, he spent a further half hour with a fellow fire-fighter from the town of Dryden, Mr Craig Bulloch, using a chain saw from Red 1 to clear a trail through the wooded area from the aircraft crash site to Middle Marker Road. Thereafter, Mr Rivard, Mr Kruger, UT of O and the Town of Dryden fire-fighters and others assisted survivors of the crash in making their way to Middle Marker Road and transporting injured passengers in stretchers to ambulances. Shortly after 1:30 p.m., when the UT of O fire-fighting vehicles drove down Middle Marker Road, Mr Rivard assisted other UT of O fire-fighters in extending a handline from the UT of O pumper truck to the aircraft crash site. Water and foam were first applied to the burning aircraft at approximately 2:00 p.m.

Use of Fire-fighting Equipment Available at the Crash

Airport CFR fire-fighting equipment that arrived at the scene of the crash were:

- Red 1, a rapid intervention vehicle carrying 300 gallons of premixed water and foam, 300 pounds of dry chemical, and equipped with a dual-agent handline 150 feet long on either side of the truck (the lines could not be joined together);
- Red 2, a crash response tanker vehicle holding 1000 gallons of water and separate foam tank and equipped with connectible 2½-inch 50-foot and 100-foot handlines with a total length of 600 feet (a 100-foot section of 2½-inch hose with connections weighs 11 kilograms); and
- Red 3, a four-wheel drive suburban van equipped with three communications radios and carrying two 30-pound fire extinguishers. Its radios are a 10-frequency VHF scanner that receives only, a two-channel FM two-way radio used for communicating between airport vehicles and offices and the Town of Dryden Fire Department, and a single frequency VHF radio for communicating between airport vehicles and the Kenora Flight Service Station.

Red 3 and Red 1 arrived at the scene of the crash at 12:18 p.m., less than 10 minutes after the crash, and Red 2 arrived at 12:43 p.m., approximately 33 minutes after the crash.

The UT of O fire-fighting vehicles that arrived in response to the crash were a self-contained rapid attack vehicle carrying water, unmixed foam concentrate, and about 1000 to 1200 feet of fire hose, and a tanker truck carrying about 1000 gallons of water, unmixed foam concentrate, and a port-a-pond water tank. The two UT of O fire-fighting vehicles arrived at 12:34 p.m. and 12:40 p.m. respectively, less than 30 minutes after C-FONF crashed. Three fire-fighters arrived with the UT of O fire vehicles, with additional fire-fighters arriving continually in their private vehicles. UT of O Fire Chief Roger Nordlund arrived at the crash site at 12:45 p.m.

The Town of Dryden Fire Department dispatched two vehicles to the crash site after a request was made by Chief Parry at 12:26 p.m. for a pumper truck. The Town of Dryden pumper truck, a suburban van, 10 fire-fighters, and two fire captains arrived at the intersection at 12:44 p.m., 34 minutes after the crash. (Mr Louis Maltais, the fire chief for the Town of Dryden, testified that, because all the fire-fighting equipment from the airport had been committed to the crash site, he sent the town's pumper truck to the airport fire hall at approximately 2:30 p.m. to provide CFR coverage for any incoming aircraft.)

By 12:45 p.m., approximately 35 minutes after the crash, there were seven fire-fighting vehicles near the scene of the crash from three fire-fighting units. Three of the vehicles, the CFR truck Red 2, the UT of O pumper truck with portable tank, and the Town of Dryden pumper truck were capable, with the use of their extended fire hoses, of delivering water and/or water and foam to the burning aircraft. However, no attempt was made to use any of the fire-fighting equipment on the peripheral fires and burning aircraft until after 1:30 p.m., when the UT of O tanker truck was driven down Middle Marker Road to a point within 150 yards of the crash site. Extinguishing and controlling the fire was not commenced until approximately 2:00 p.m., one hour and 50 minutes after the crash, when the first water and foam mixture was applied by UT of O fire-fighters.

There were two 30-pound, cartridge-activated fire extinguishers on Chief Parry's suburban vehicle, Red 3. One was a standard multipurpose, dry chemical extinguisher, and the other was specifically for metal fires such as wheel brake fires. Neither extinguisher was used on the aircraft fire. Chief Parry gave the following reasons for not using these extinguishers:

> A. ... I knew that it was an F-28 that had gone down in heavy bush. I had seen smoke from a distance and both arriving and the

> magnitude of that disaster was not going to be affected in any significant manner by a 30-pound extinguisher.
>
> (Transcript, vol. 6, p. 251)

When questioned further, however, Chief Parry agreed that these fire extinguishers could have been used to contain spot fires and flare-ups described by rescuers who arrived early at the crash site.

In discussing the use of rapid intervention vehicle, Red 1, for fire-fighting, Chief Parry stated that Red 1 does not have handlines suitable for use away from the immediate vicinity of the truck. He stated in testimony that "it has a fixed dual agent handline which is extremely heavy and short. It is intended for immediate mop-up use in the close proximity" (Transcript, vol. 7, pp. 10–11). The suburban vehicle, Red 3, parked at the intersection all afternoon, was used as a command post by Chief Parry.

During testimony, Chief Parry explained why he did not instruct Mr Rivard in Red 2 to proceed back down Middle Marker Road and position the vehicle close to the crash site:

> A. We already had a pumper truck in that area. A pumper truck can be supplied with water. It has drafting capability. It also carries a great deal of hose. It was sent in there initially.
>
> (Transcript, vol. 6, pp. 253–54)

Chief Parry was referring to the UT of O pumper truck that arrived at the intersection at 12:40 p.m. and parked on McArthur Road three minutes prior to the arrival of Red 2. While Chief Parry admits that he made an error in signalling Red 2 to go down Middle Marker Road when it first arrived, he stated that his action was a "natural instinct" and he waved Red 2 in, not realizing that there was an ambulance already down Middle Marker Road.

In Chief Parry's view, Red 2's fire-fighting capability would have been less effective than the UT of O pumper truck and, in his words, it would have been "perhaps disastrous" for the CFR fire-fighters to "try and set that up and get those handlines in" from Red 2 (Transcript, vol. 6, p. 255). Chief Parry felt that it would have taken the efforts of Mr Kruger, Mr Rivard, and himself just to string the 500 feet of fire hose into the crash site, and "that it probably would have taken us a long time, just three of us mainly, trying to get that hose in there" (Transcript, vol. 6, p. 255). Chief Parry was also of the view that he would have lost the coordination aspect of "getting all those other resources there. In my opinion, that would have been disastrous" (p. 256). Chief Parry stated in testimony that, even if it was physically possible for the three CFR personnel to hook up the links of hose and string the line from Red 2, it would have been a 20- to 30-minute operation. Based on his experi-

ence from previous exercises, Chief Parry elected to man his command post and he stayed there, in his words, "[a]s much as I possibly could" (p. 257).

Chief Parry explained that he did not instruct Red 2 to proceed back down Middle Marker Road because Red 2 would have been less effective than the UT of O pumper truck. While he explained why the UT of O pumper truck would be more effective, Chief Parry had no explanation of why the UT of O pumper truck was not directed down Middle Marker Road to a position near the crash site as soon as possible after its arrival. Chief Parry stated in testimony that:

> A. ... what really happened ... the UT of O pumper truck showed up around about the same time as the Red 2 and I instructed them to go in and see if they could get a handline in ... when the UT of O pumper truck showed up, it was the first thing I said to them. See if you can get a handline in there.
>
> (Transcript, vol. 8, p. 15)

The UT of O fire-fighter who drove fire truck number 2, the tanker truck, was Mr Gerald McCrae. He testified that when he arrived at the intersection, he was instructed by an OPP officer standing next to a police cruiser to park the truck off to the right out of the road. Someone then told Mr McCrae that "we need back boards" (Transcript, vol. 8, p. 242). Mr McCrae found two mini-stretchers in the back of Chief Parry's van and ran down Middle Marker Road. Mr McCrae stated that there were all kinds of survivors walking out as he was running down Middle Marker Road. He followed a path into the crash site and came upon survivor Mrs Nancy Ayer, 40 feet from the aircraft, and immediately assisted her. Mr McCrae, with the help of Dryden airport employee Allan Haw, Terraquest pilot Craig Brown, and surviving passenger Alfred Bertram, carried Mrs Ayer to Middle Marker Road, transported her to the intersection, and placed her in an ambulance. Mr McCrae stated that no one in the UT of O made an effort to take either the pumper truck or the tanker truck down Middle Marker Road. As he explained, "[w]e more or less did what we were directed to do when we arrived on the scene" (Transcript, vol. 8, pp. 269–70). He does not recall who gave him the instructions to take stretchers and back boards to the site, but he perceived his role at the time to be one of rescue of survivors as opposed to fire suppression.

Whether Chief Parry made a request to "see if they can get a handline in there" will not be definitely known. The request either was not made, was not heard, was not remembered, or was ignored by the UT of O fire-fighters. Nor did the UT of O fire-fighters take the initiative to take a handline into the crash site. The UT of O pumper truck was not driven down Middle Marker Road until sometime after 1:30 p.m. A briefing

took place between Chief Parry and UT of O Fire Chief Nordlund, when the latter arrived at 12:45 p.m., only minutes after the arrival of the UT of O tanker truck. Chief Nordlund was advised by Chief Parry of the steps he had taken in alerting various parties, but there was no discussion as to what each was going to do, and no discussion regarding the use of handlines. Chief Nordlund thereafter proceeded, as did many of his fire-fighters, immediately towards the crash site. In making his way into the site, Chief Nordlund assisted carrying stretchers part way out to Middle Marker Road. He stated that he "eventually got in to the fire scene and took a minute or two just to assess what was going on" (Transcript, vol. 8, p. 109).

Mr Rivard agreed that Red 2 could have been moved back down Middle Marker Road, close to the crash site. He also agreed that he could have rounded up several rescuers and run the handline from Red 2 to the crash site. It was Mr Kruger's evidence that coupling two sections of hose together would take only a matter of seconds. In reconstructing the time that it might have taken a fire-fighter, with the assistance of civilian rescuers, to extend the 500 feet of hose from Red 2, Mr Kruger estimated that it would be 15 or 20 minutes. He also stated that a handline would have assisted in the rescue effort of the last two passengers removed from the aircraft, Mr Uwe Teubert and Mr Michael Kliewer. In testimony, Chief Nordlund stated that it would take one fire-fighter and two to three volunteers less than five minutes to extend 500 feet of hose, in four 100-foot sections and two 50-foot sections, to the crash site.

During testimony, although Chief Parry agreed that providing a fire-free escape route for the passengers and crew of a burning aircraft was his primary responsibility, he stated that, in this case, "that was not possible" (Transcript, vol. 7, p. 48). Because he thought that the aircraft had crashed some distance into the bush, because the smoke and perhaps the fire had died down, and because it was his own belief that the chances for survival of anyone in the crash were slim, Chief Parry did not even consider running a fire hose through the bush into the crash site from Red 2. It was Chief Parry's view that his first priority was getting in a great deal of help, and that neither he nor his crew chief and his fire-fighter were going to make any significant difference by themselves.

When asked if it was his obligation to make efforts to contain the fire at the crash site, Chief Parry stated, "No, it was not. By that time, I had injured people under my care" (Transcript, vol. 7, p. 42). Chief Parry's view of his obligations at the crash site illustrates the depth of his misunderstanding of his responsibility as the CFR chief.

In discussing the use of the CFR tanker truck Red 2, Chief Parry indicated in testimony that the election not to use Red 2 and its fire

hoses immediately to extinguish the fire at the crash site was "fortuitous" (p. 68). One could infer from this evidence that Chief Parry considered it more important to conserve the fire truck water supply than to use it to suppress the fire. In explaining this apparently incongruous position, he stated as follows:

> A. Once it was set up, if it had been set up and in use, it has a limited water supply and has no drafting capability, so once the truck is empty, it will just sit there and be an obstruction for the remainder of the duration, whereas a pumper truck, which was the unit that was on site, carries more hose, has much more versatility, has unlimited water supply in that it can draft and can be supplied by tankers.
>
> (Transcript, vol. 8, p. 64)

Fire-fighter Rivard, during testimony, had a different view. In proper circumstances, handlines from both tanker truck Red 2 and the UT of O tanker truck could have been used at the crash site.

Chief Parry agreed during testimony that although a continuous stream of foam mixture from the fire hose lasts approximately eight to nine minutes, he also admitted that it would last considerably longer if the operator of the hose used short bursts rather than a continuous stream. Chief Parry agreed that the foam was available immediately from fire truck Red 2. The UT of O pumper truck carries and is equipped to use the same A Triple F foam as described below.

Mr Thomas Harris was a passenger on flight 1363 and the only one who escaped out the left emergency exit, receiving severe burns to his hands in the process. At that time, he was the senior technical assistant at Abitibi Price in Thunder Bay, and he is a chemical engineer. In testimony he stated that he had seen intense fire and training films of aircraft fires and fire-fighting, and that he had seen how easily these fires can be extinguished with proper fire-fighting equipment and foam.

Mr Harris stated that, when he escaped from the wreckage, the flames were two to five feet high. About 10 minutes after the crash, he saw two rescuers arrive, one a fire-fighter (later identified as Mr Kruger) and the other a non–fire-fighter. At this time, the flames were 5 to 10 feet high on the left side of the aircraft, and Mr Harris was of the opinion that had the rescuers had a fire hose they could have extinguished the fire at that point in time. This may be true, but, as explained in chapter 8, Dryden Area Response, the earliest that a handline could have reached the aircraft was approximately 12:50 p.m., some 25 minutes later.

Experts' Views of CFR Activities March 10, 1989

Mr Brian Boucher

Mr Brian Boucher, an Air Canada pilot and trained specialist in aircraft fires, testified that the foam supplied by Transport Canada for use in Red 2 is probably the best foam on the market and is recommended for use at all airports. He stated that Red 2 was carrying aqueous film-forming foam, commonly referred to as A Triple F. Mr Boucher described the fire knock-down characteristics of that foam as superb. Having listened to Mr Kruger's testimony as to the state of the fire on his arrival at the crash site and having spoken to him personally, Mr Boucher thought that a fire-fighter with a handline using the foam from Red 2 could probably have knocked down the major part of the fire in 10 minutes, and it could have taken 20 to 30 minutes to extinguish the fire completely. In Mr Boucher's opinion, the fuselage would have been saved from complete destruction by the fire and the flight data recorder would have been saved had a handline been brought in immediately. Mr Boucher stated:

> A. ... The fire hadn't penetrated past the floor. The fire was burning in the ceiling. The fire burned downwards. It didn't start impinging on the flight data recorders until later on in the fire. So if that fire would have been knocked down within ... 15 minutes, 20 minutes, the way the flight data recorders are designed to sustain a certain amount of heat, as you have already heard testimony from, it's most likely, most probable that those flight data recorders would have been saved.
>
> (Transcript, vol. 68, pp. 113–14)

It should be noted that the Dryden airport CFR unit supplies the UT of O Fire Department with A Triple F foaming agent for use on aircraft fires, and that that foam was used by the UT of O on March 10, 1989.

Mr Jeffrey Hamilton

Mr Jeffrey Hamilton, the Transport Canada emergency services officer who provided expert evidence on a number of matters, was specifically asked to assess the Dryden CFR unit's response to the crash. As well, he was asked to give his opinion on the procedures used during the hot refuelling and on the fact that the CFR did not keep the access roads clear of snow.

It was Mr Hamilton's opinion that a properly trained CFR fire-fighter would not have lost control of his vehicle turning off the runway and should have proceeded with a little more caution. He was of the view that the maintenance road from the fire hall to the runway should have been kept sanded. Mr Hamilton testified that Mr Rivard should not have

stopped to top up Red 2 with water. The loss of brakes on Red 2, due to a known and repairable defect in the braking system of the vehicle was unacceptable. While Mr Hamilton agreed with Chief Parry's action in manning a communication post at the intersection of McArthur Road and Middle Marker Road, he stated that Chief Parry should have ordered the lines from the UT of O pumper truck to be taken in to suppress the aircraft fire. In Mr Hamilton's view, that order should have been given immediately. In addition, Mr Hamilton testified that crew chief Kruger should not have given up his fire-fighter's coat, a piece of protective apparel, to one of the survivors.

Mr Hamilton concluded that the response by the Dryden CFR personnel to the crash of C-FONF was unacceptable, and he agreed that lack of training was the cause of some of the errors made by the fire-fighters. Mr Hamilton stated that this lack of training and knowledge should improve in the future, not only at the Dryden airport but at all Transport Canada–owned, operated, and subsidized airports, through the introduction of Transport Canada's Firefighter Certification Program. This program, in the words of Mr Hamilton, "will bring every firefighter in the region, or the country for that matter, to the same level of training, both practical and theoretical in every aspect of their job" (Transcript, vol. 34, p. 14).

Mr Larry O'Bray

At the time of the crash, Mr Larry O'Bray was superintendent of CFR services, Transport Canada, Central Region, and, as such, was responsible for implementing and overall coordination of Transport Canada's CFR programs within Central Region. This included assisting and advising airport managers in the running of their CFR programs, conducting training programs, and evaluating CFR units within Central Region. Both emergency services officers, Mr Jack Nicholson and Mr Jeffrey Hamilton, reported to Mr O'Bray.

In mid-January 1990 Mr O'Bray and Mr Nicholson visited the Dryden airport and reviewed with the CFR personnel their response to the Air Ontario crash. The purpose of their visit was to discuss the implementation of Transport Canada's new Firefighter Certification Program with Airport Manager Louttit and Fire Chief Parry and to review the events of March 10, 1989, including the errors made and procedures that should have been followed by the CFR unit.

During testimony, Mr O'Bray summarized his review of the initial response of the CFR unit and the UT of O Fire Department. He approved of Mr Kruger's going to the crash site to assess the fire; however, he was critical of Chief Parry's lack of communication with the UT of O fire chief upon the latter's arrival. As an expert CFR fire-fighter, Mr O'Bray was of the view that many of the fire-fighters became

distracted when they arrived at the crash site. He stated that their distraction was, to some extent, due to lack of training and repetitive drills and lack of knowledge.

Mr O'Bray pointed out that there was ample evidence over the years from the training reports provided by Chief Parry and Mr Louttit, the airport manager, to Transport Canada and from the evaluations conducted by Transport Canada to show that the Dryden CFR unit was not properly trained to Transport Canada's "full standard" (Transcript, vol. 36, p. 14).

I share Mr O'Bray's view that such crash-site distraction could occur to any inadequately trained fire-fighter, and that there should be a training program within Transport Canada aimed at preparing CFR crews for the realities of a catastrophic aircraft crash such as occurred at Dryden. I am satisfied from the evidence that the underlying cause of the distraction of the CFR fire-fighters was, in large part, the result of inadequate fire-fighter training and lack of repetitive drills by the CFR unit.

Aircraft Crash Charts

Transport Canada's airport emergency services fire-fighter training standards document AK-12-06-002 requires fire-fighters to have a thorough knowledge of items that are critical to an aircraft accident or incident response. Paragraph 3.03 states as follows:

> 3.03 Aircraft
>
> AES personnel shall possess a comprehensive knowledge of all aircraft in continuing and regular use at their respective airports. This knowledge shall be acquired through training and independent study. The required knowledge will include configurations, construction, passenger capacity, fuel capacity, and location of exits. An associated requirement is a detailed knowledge of the hazards associated with aircraft, i.e., aviation fuels, jet engines, propellers, wheel fires, explosives, helicopter rotors, etc. The Fire Chief shall, through regular testing, ensure that each person is current and adequate in his/her knowledge. Firefighters shall have a detailed knowledge of the various types of aircraft incidents, their peculiarities, and generally accepted practices in approaching each. Based on the required knowledge of aircraft, airports, and accepted basic tactics, appropriate tactics shall be developed by the Fire Chief.
>
> (Exhibit 244)

Mr Jack Nicholson, the Transport Canada Central Region emergency services officer responsible for evaluating the Dryden CFR unit at the time of the crash, testified that an important element of the knowledge

required by fire-fighters is provided by aircraft crash charts. Witnesses who gave evidence on this subject agreed that aircraft crash charts are essential for the identification of the critical areas that fire-fighters must be aware of in their response to potential or actual aircraft accidents or incidents. Accordingly, it is important for airport CFR units to obtain crash charts for each aircraft that uses their airports on a regular basis.

The crash chart of a Fokker F-28 Mk3000 and 4000[3] (see figure 9-2) provides critical information for fire-fighters and rescuers regarding the location and operation of doors and emergency exits, passenger seating arrangements and escape routes, and location of hazardous items such as aviation fuel, batteries, high pressure lines and reservoirs, and onboard fire extinguishers. The crash chart also shows the location of the aircraft flight recorders.

At the time of the crash of C-FONF on March 10, 1989, the scheduled passenger-carrying aircraft using the Dryden Municipal Airport most frequently were the Fokker F-28 jet aircraft operated by Air Ontario and the British Aerospace Jetstream 31 turboprop aircraft operated by Canadian Partner. Air Ontario also operated the de Havilland Dash-8, the Convair 580, and the HS-748 turboprop aircraft into the Dryden Airport from time to time. Chief Parry testified that, of the five aircraft listed, the Dryden CFR unit had in its possession a crash chart for only the HS-748 aircraft. The fact that there was no F-28 crash chart available to the CFR may have been of significance in the case of the Dryden crash.

There was no doubt in the minds of both Chief Parry and Crew Chief Kruger that crash charts are valuable and necessary tools to inform fire-fighters of the critical areas of an aircraft that will be of concern in any emergency. The evidence shows that obtaining crash charts, at least at the Dryden Municipal Airport, was left up to the fire chief, with no assistance or direction from Transport Canada as to how they were to be obtained. Chief Parry testified that he received a Fokker F-28 Mk3000/4000 crash chart, depicted above, only days before he appeared before this Commission of Inquiry as a witness, more than three months after the F-28 crash. He also testified that when he contacted Boeing-de Havilland Aircraft for a Dash-8 chart, he was advised that they did not have a crash chart for the Dash-8. As a case in point, I was surprised to hear during the course of Transport Canada witness testimony that crash charts for the Boeing 747-400 series aircraft, one of Boeing's newest aircraft, were not at that time available at airports such as Lester B. Pearson International Airport, Toronto. This Boeing 747-400 aircraft differs from other Boeing 747 aircraft in that there is a fuel tank in its

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[3] The crash chart for the Fokker F-28 Mk1000 aircraft shows that the layout and configuration of a Mk1000 are similar to that of a Mk3000 aircraft.

vertical stabilizer. I have no doubt that there is information on other differences in this aircraft that could also be used by CFR units.

The problem of lack of aircraft crash charts is not isolated to the Dryden Municipal Airport. During testimony, Mr Nicholson stated that there was no Transport Canada policy that he was aware of requiring crash charts to be made available at any airport. However, it was the responsibility of the fire chief to ensure that the CFR fire-fighting crews possessed information of the type contained in crash charts. Testimony of other Transport Canada witnesses revealed that Transport Canada left it to individual fire chiefs at airports operated by Transport Canada to ensure that crash charts of aircraft that used the airport on a regular basis were available to the CFR unit.

The fact is that fire chiefs may not be in the best position to obtain or demand aircraft crash charts from either the manufacturer or from an aircraft operator. I am of the view, having heard the evidence, that the onus should be placed on the carrier to provide the CFR unit at any airport used by the carrier with a crash chart for every aircraft it operates into that airport.

I will not review in detail all the testimony dealing with the necessity for crash charts to be available to CFR fire-fighters. Suffice it to say that crash charts are an important tool which, together with actual visual inspection of an aircraft, enable fire-fighters to familiarize themselves with components of the aircraft that may be critical in any aircraft crash, fire, or rescue scenario. Crew chief Kruger in testimony confirmed that, after saving lives, his secondary mandate is the preservation of evidence and the protection of the accident site. He stated that preservation of evidence "is a very fundamental and important one" (Transcript, vol. 26, p. 143).

It is reasonable to assume that if the Dryden CFR unit had been more familiar with F-28 aircraft through study of its crash chart and a thorough familiarization of the critical aspects of the aircraft, including the aircraft flight recorders, all of the crew, including the fire chief, may have been more alert to the need to attempt to control the aircraft fire and preserve the aircraft structure. Testimony revealed that the CFR fire-fighters did not know where the F-28 aircraft flight recorders were located. Clearly the chances that the recorders might have been saved from destruction, and the information therein used in analysing the cause of this crash, would have been increased had the Dryden CFR unit had crash charts. It was estimated that the recorders were exposed to an average temperature of 850°C for two hours, which destroyed the tapes. Reducing the time that the recorders were exposed to high temperatures would have increased the likelihood that the information stored in them would have been recovered.

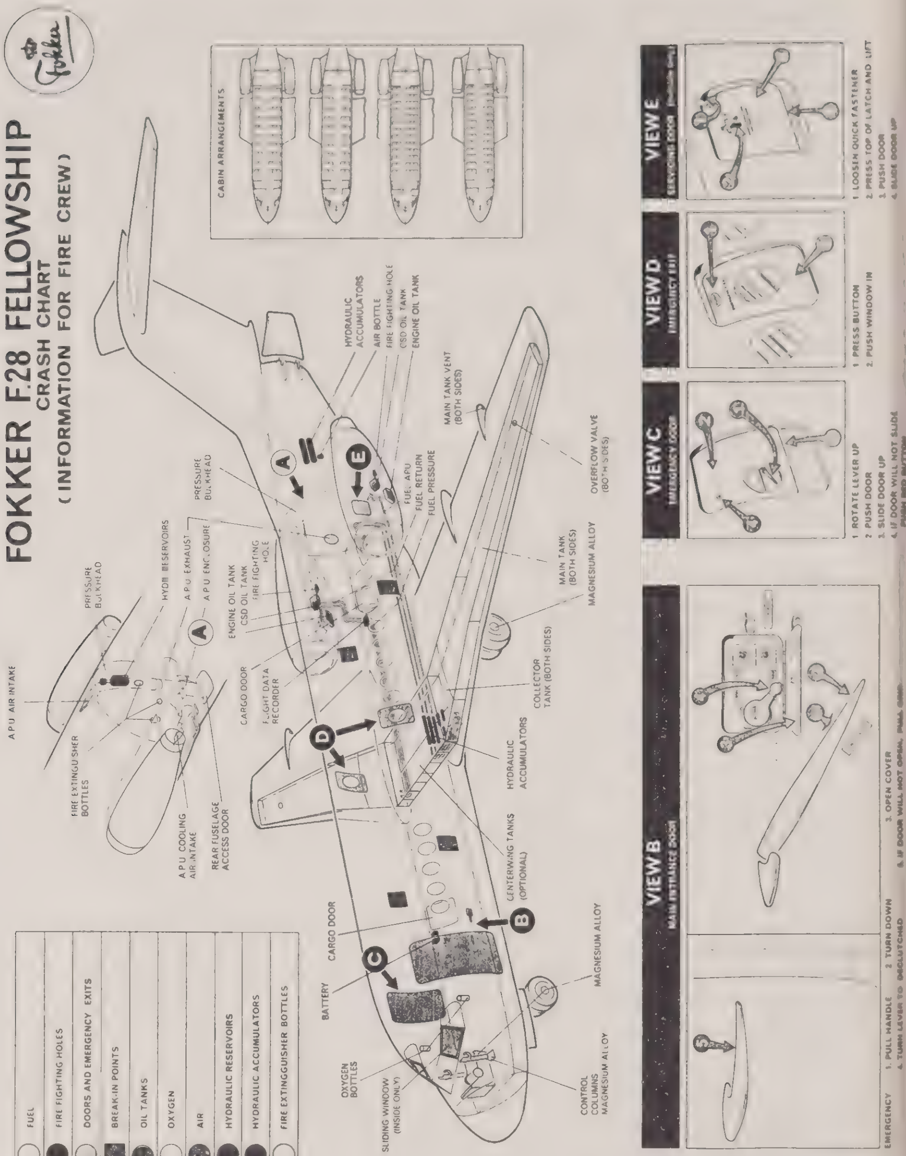
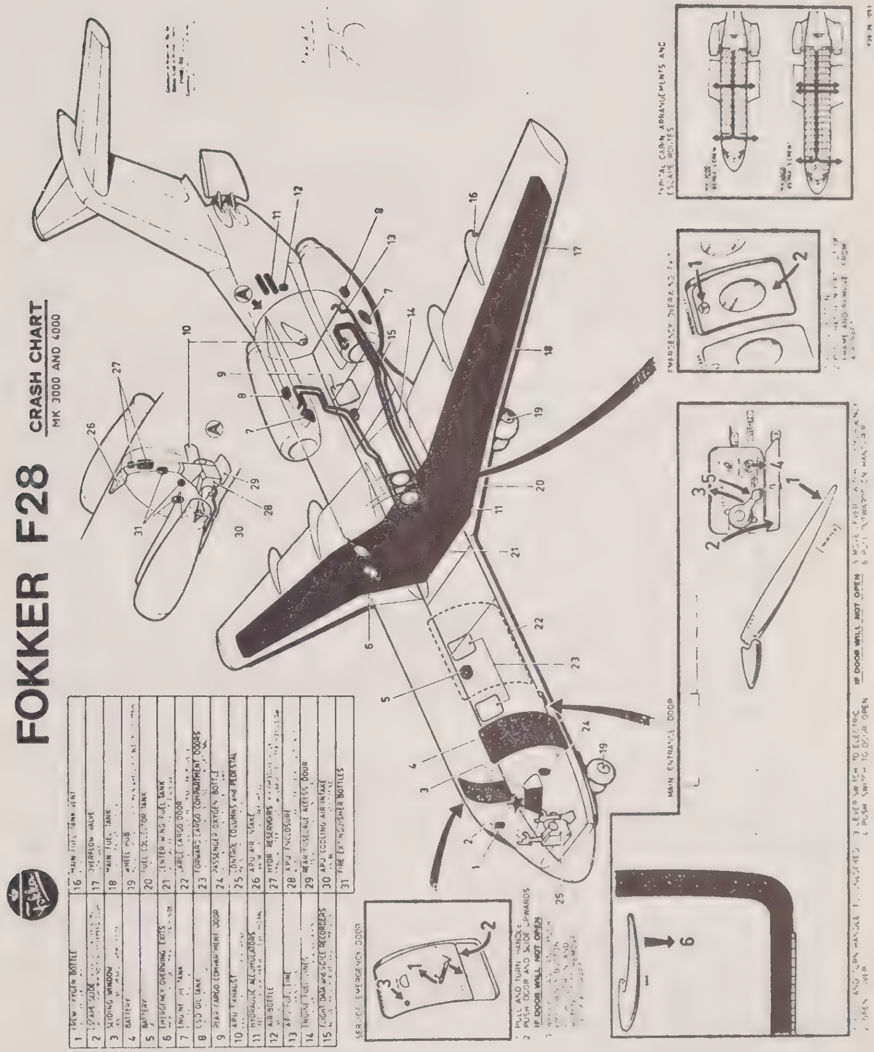


Figure 9-2 Fokker F-28 Crash Charts



Fokker F-28 Mk1000
Source: Fokker Aircraft

As a result of this crash and the testimony heard before this Inquiry regarding the unavailability of crash charts, Mr Henry Moore, director, Airport Safety Services, Transport Canada, testified that in August 1989 his staff conducted a survey to determine the availability of crash charts on a national basis. Based on that survey, Mr Moore stated that Transport Canada was not "as well prepared" as it should be regarding crash charts. As a result of this survey, Transport Canada issued a policy directive instructing all Transport Canada Regions as follows:

> **CRASH FIRE RESCUE – AIRCRAFT CRASH CHARTS**
>
> Headquarters, AKOB, have recently completed a survey on the availability of aircraft crash charts at all airports.
>
> While it appears that, for the most part, charts are available, it is evident that not all aircraft are covered, and not all charts are up to date. It is therefore suggested that Regional CFR staff provide guidance and assistance to airports within their area of responsibility to ensure the following:
>
> – Up-to-date crash charts for all regularly scheduled, charter and/or cargo aircraft are obtained.
> – Copies of charts are carried on each CFR vehicle, in the fire hall for training purposes and in the ECC.
> – CFR personnel conduct familiarization exercises on all aircraft, using their airport as part of their regular training program.
> – Crash charts on all other aircraft using the airport are also recommended.
>
> Once you are satisfied that this very important requirement has been met, it would be appreciated if this Headquarters (AKOB) is advised.
> (Exhibit 272)

I am advised that Transport Canada's instructions to the regions regarding provision of crash charts to all CFR units apply to CFR units at subsidized airports as well as to Transport Canada–owned and operated airports. Mr Moore also testified that Transport Canada will in the future require manufacturers and operators of new aircraft to provide to Transport Canada, as a requirement of the aircraft type approval, a crash chart of the aircraft for distribution by Transport Canada to all airports. Transport Canada issued a policy letter, dated February 6, 1991, stating in part:

> POLICY STATEMENT
>
> All Canadian air carriers introducing new aircraft types or aircraft that have not been operated in Canada will be required to provide

> aircraft crash charts. This information will be required 25 working days before the aircraft may be used in a commercial air service.
>
> PURPOSE
>
> To ensure service that Emergency Response Service (ERS) formerly Crash, Fire, and Rescue (CFR) units, at airports, have up-to-date crash charts before an aircraft goes into service.

This policy letter will be incorporated into the next amendment of Transport Canada Air Carrier Certification Manual.

I agree with the action taken by Transport Canada in both ensuring that requisite crash charts of aircraft using airports on a continuing and regular basis be made available to all CFR units and in requiring all Canadian air carriers introducing new aircraft types or aircraft that have not been previously operated in Canada to provide crash charts to Transport Canada.

I wish to emphasize that these crash charts should be made available to all airports, whether they are Transport Canada–owned and operated or subsidized and community airports. If passenger-carrying scheduled carriers use an airport on a regular and continuing basis, these charts should be at that airport.

Training and Proficiency of Dryden CFR Unit Personnel

Transport Canada Training Policy

The Transport Canada Firefighting and Rescue Services training standards manual, which was in effect at the time of the crash, states that it is Transport Canada's policy that:

> Crash Firefighting Rescue Services will be provided at all airports operated by Transport Canada that are used by commercial air carriers on a regularly-established basis.

It is further stated that:

> Crash Firefighting Rescue Services, whose duties consist of the provision of aircraft crash fire protection services, are infrequently called upon to face a serious situation involving a major aircraft accident. It follows that only by means of a most carefully planned and executed program of training, can there be any assurance that both men and equipment will be ready to cope with a major aircraft

> fire should the need arise. Training requirements fall into two broad categories: initial training and ongoing training.
>
> (Exhibit 243)

This Transport Canada manual further states that the objective is "to provide highly trained AES (Airport Emergency Services) personnel capable of carrying out prevention, control and suppression." The document contemplates that training programs shall elevate AES personnel to and maintain them at a high level of knowledge and skills relevant to fire prevention, control, and suppression. Airport fire-fighters are required to possess a comprehensive knowledge of and be highly skilled in the operation of all AES vehicles at their respective airports. The manual states that fire-fighters should possess a comprehensive knowledge of all aircraft in continuing and regular use at their respective airports. They should also possess detailed knowledge of their airports and those areas immediately surrounding the airport, be aware of all natural and man-made hazards in their area of operations, and acquire, through training and study, a knowledge of the most direct and secondary routes to all points within their area of operations. The manual contemplates that, in all cases, the fire chief should ensure by training, regular examination, and testing, that each fire-fighter is current, has adequate detailed knowledge of, and demonstrates competency in all aspects of his or her duties and responsibilities.

The Transport Canada Safety Services Branch in Central Region, within which the Dryden area is located, consisted, at the time of the crash, of three experienced CFR fire-fighters (a superintendent, Larry O'Bray, and two emergency services officers, Jack Nicholson and Jeffrey Hamilton).

The branch is responsible for either evaluating or training CFR units at 23 airports, some of which are owned and operated by Transport Canada, owned and subsidized by Transport Canada, or owned by Transport Canada and contracted out for operation (see figure 9-3). According to Mr O'Bray, half the airports subsidized by Transport Canada are located in Central Region.

The branch reports and provides advice on Central Region CFR matters to superiors in Central Region and in Ottawa. It also provides training, evaluation, advice, and guidance regarding CFR, crash protection, and fire prevention programs to airport managers and fire chiefs in the region. By necessity, Mr O'Bray's organization relies almost exclusively on the airport managers and the fire chiefs to maintain the proper level of knowledge, training, and proficiency of CFR fire-fighters and to ensure that all airport equipment and facilities are in proper operating condition. In the normal course, Transport Canada expects that a fire chief at a Transport Canada–operated airport has a number of years' experience in crash, fire, rescue, and in general fire-fighting. Some

of that experience should be in a supervisory capacity. Transport Canada attempts to obtain by competition the best qualified people within its organization to take the position of fire chief. Accordingly, Transport Canada has some control over who is placed in the position of fire chief at a Transport Canada–owned and operated airport.

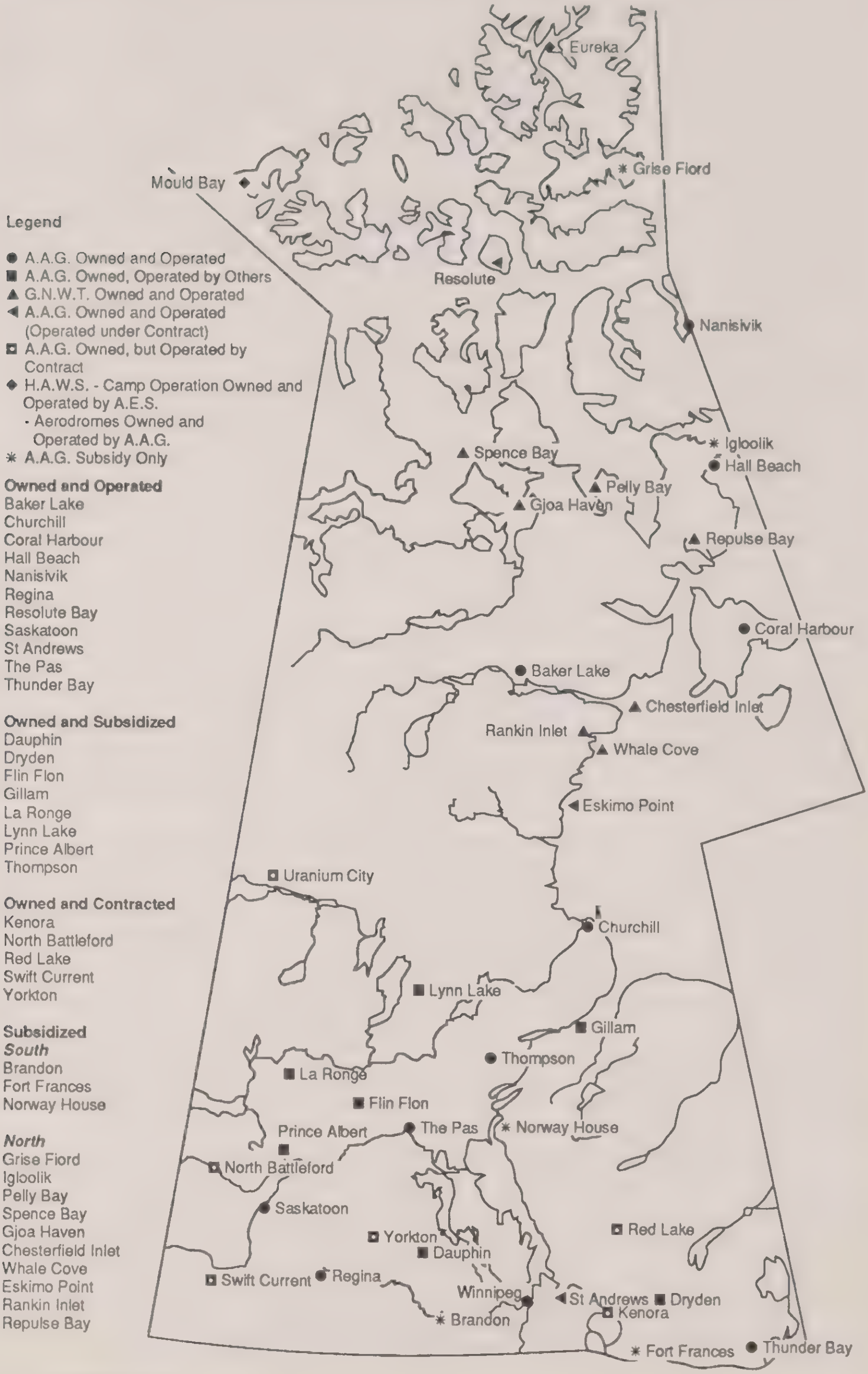
Mr O'Bray stated that a supportive and cooperative airport manager is essential to maintaining a good CFR program. In a line organization, such as Transport Canada, the airport manager is ultimately responsible for ensuring that a proper CFR program is maintained at the airport. If that airport manager does not ensure that a proper CFR program has been implemented and maintained, then Mr O'Bray's branch may provide advice to the regional director general or the director of operations within Central Region Airports Authority Group, who will then ensure that a specific airport manager comply with Transport Canada policy documents. Airport managers of international airports, such as the Winnipeg International Airport, located in Central Region, however, report directly to the director-general, Airports Operations Directorate, Transport Canada Headquarters, Ottawa. In summary, airports owned and operated by Transport Canada must comply with the CFR standards and requirements as set forth in the various Transport Canada policy AK documents.

Mr O'Bray explained that he conducts two initial training courses in Central Region each year for CFR personnel, a two-week course designed for professional fire-fighters and a one-week course designed to train auxiliary fire-fighters. Professional fire-fighters from non-Transport Canada–owned and operated airports are invited to attend the professional course.

In addition, Mr O'Bray's Safety Services Branch evaluates each of the professional CFR units within Central Region once each year. This evaluation consists of attendance at the airport, briefings with the airport manager and the fire chief, and evaluation of the fire-fighting unit's capability through various drills and exercises. The CFR chief and airport manager are debriefed after the evaluation, and a written report is provided to the airport manager. The Safety Services Branch expects training to be carried out by the fire chiefs on a regular basis and provides annual training courses to auxiliary CFR units to enhance their own training programs.

During testimony, Mr Hamilton defined a "professional" fire-fighter as one who is a paid, full-time, dedicated CFR unit member responsible for fighting fires and carrying out the airport CFR program, which includes airport fire prevention. Mr Hamilton cited the Brandon Airport as one that has a mixed fire-fighting staff, the fire chief being a full-time, salaried, dedicated fire chief and the remaining fire-fighters being auxiliary staff from the airport.

Figure 9-3 Airports and Aerodromes in Central Region



Source: Exhibit 245

Mr Hamilton, during his evidence, described the duties and responsibilities of fire-fighters, fire officers, and the fire chief in day-to-day operations. He gave evidence that, in addition to conducting normal duties during a shift, each fire-fighter must complete two hours of training each day averaged over a period of one month. Fire officers, in addition to being responsible for their own fire-fighter duties and training, are tasked with supervising their shift of fire-fighters and are responsible for ensuring that the duties of the shift are carried out. A fire officer also must ensure that the training program laid out by the fire chief is properly conducted. The fire chief, who is responsible for ensuring that he himself is properly trained as a fire-fighter, is responsible for designing the training program for CFR fire-fighters and ensuring that it is carried out. While he may delegate the responsibilities for training to others, as the administrator of the fire hall, the chief has the ultimate responsibility for its operation, including the posting of each month's schedule of training. All training, programs, and duties are to be conducted in accordance with Transport Canada AK policy documents.

All Central Region fire-fighters write Central Region examinations semi-annually, and they write a headquarters' examination annually. Fire officers are responsible for testing and examining fire-fighters on a regular basis. In addition to their own testing, fire officers are evaluated yearly by the fire chief. The fire chief is responsible to the airport manager for ensuring that all CFR examinations and tests are conducted in accordance with Transport Canada AK policy guidelines. There is no provision in Transport Canada that requires a fire chief to take the examinations that are required of fire-fighters and fire officers. It is expected by Transport Canada that fire chiefs will ensure that each of the CFR fire halls has a library of required Transport Canada AK documents, manuals, and appropriate National Fire Protection Association (NFPA) manuals, and it is mandatory that the fire-fighters conduct a self-study program of all these manuals and documents. It is the responsibility of the fire chief to produce the training schedule, and it is the responsibility of the fire officers and individual fire-fighters to ensure that the study and training are completed.

In addition to the yearly evaluation conducted by the Safety Services Branch on each CFR unit within Central Region, the Safety Services Branch relies on CFR training reports prepared by the fire chief and reviewed and forwarded by the airport manager to Central Region, Safety Services. These reports are made on a detailed form with provisions for the fire chief to list the training conducted during any six-month period in the following areas:

- training fires
- training materials
- vehicle driver training
- aircraft familiarization
- regional conducted training
- other aircraft practical training
- structure practical training
- theory training
- films shown
- Emergency Services (CFR) Chief remarks
- Airport Manager remarks
- Region remarks
- HQ remarks.

The annual evaluations provide Transport Canada with an opportunity to review an airport's facilities, inspect vehicles and equipment, and evaluate the ability of the CFR fire-fighters to respond to an emergency. On most airports there is located away from runways and buildings a specially constructed fuel burn area where CFR personnel can conduct live fire exercises. This allows the use of vehicles and handlines in extinguishing fuel-fed fires similar to those expected on a crashed aircraft.

A major part of CFR training is directed to the fire-fighters' ability to respond to a burning aircraft. Live-fire (''hot-drill'') training exercises are conducted during annual courses run by Safety Services Branch. Regular hot-drill exercises are also conducted by a CFR unit as part of its training program. The ability of a CFR fire-fighter to respond to live-fire situations is to be evaluated by Transport Canada Emergency Services officers on an annual basis.

Dryden Airport Management Training Policy

The Dryden airport CFR unit personnel received a two-week initial fire-fighting training course at Winnipeg in the fall of 1982, shortly after Chief Parry was hired as fire chief and the unit was staffed by full-time professional fire-fighters. Although Chief Parry had experience with a mining company as a captain on a mine fire brigade and had trained as an underground mine rescue member, he had no previous active fire-fighting experience. Unlike Transport Canada fire chiefs, who must have a previous CFR fire-fighting background and compete for the position, Dryden Airport Commission hired all their fire-fighters, including their fire chiefs, from outside Transport Canada ranks. Chief Parry did not have the fire-fighting experience Transport Canada looked for; however, it was the view of Mr O'Bray that Transport Canada could train him as

a fire chief if he was "receptive." Mr O'Bray stated during testimony that it was difficult to hire fire chiefs for subsidized airports. Although Transport Canada canvassed Transport Canada CFR fire halls in an attempt to hire a fire chief, in Mr O'Bray's words "no one would make the jump" (Transcript, vol. 35, p. 39).

By the end of the second week of the initial training course, Mr O'Bray was satisfied that the Dryden CFR fire-fighters were sufficiently trained to get involved in their own on-site training and quickly become a good crash fire rescue team. Chief Parry and the airport manager provided training reports to Transport Canada initially on a quarterly basis, and, commencing in 1987, on a biannual basis indicating materials used, training conducted, and studies completed during that period. Chief Parry and Mr Louttit used the form to address any concerns or make any remarks to Transport Canada. The Central Region Safety Services Branch began conducting annual evaluations of the Dryden airport CFR unit early in 1984. Copies of many training reports and of evaluations were reviewed.

I do not propose to review, in detail, the Dryden airport training reports or all of the evaluation reports prepared by emergency services officers; however, two matters arise from the reports and evaluations that are of concern to me. The first is the lack of training that was conducted by the Dryden airport CFR unit over the years and the continuing refusal by the airport manager and fire chief to conduct the required training, in the face of repeated recommendations by Transport Canada Central Region officials that they do so. The second matter is the inadequate manner in which Transport Canada tried to ensure that required training was being performed by the Dryden CFR unit.

It is clear from the testimony and from the documentation presented before me that, from the time the professional CFR unit was established at Dryden, Chief Parry did not have a carefully planned and executed program of training, as contemplated by Transport Canada policy documents. In addition, the evidence clearly indicates that Chief Parry was not conducting, and indeed was refusing to conduct, hot-drill training. He also was not requiring his crew chiefs to conduct sufficient hot-drill training to ensure that his fire-fighters and equipment would be ready to cope with a major aircraft fire. Airport manager Louttit supported and condoned Chief Parry's actions of reduced training as his comments on the training reports show.

While Chief Parry and Mr Louttit took the position that training was being reduced as a result of budgetary restraints, Mr O'Bray maintained that funds were always allocated and available to the Dryden airport for CFR training. Mr O'Bray testified that, while the Safety Services Branch was advising Dryden airport that funding was available and telling them to get on with training, the Dryden airport manager and fire chief

simply ignored its requests to increase the level of training and often refused to follow Transport Canada's advice and direction, each time suggesting that the cause was due to funding restrictions.

When reviewing the October 1 to December 31, 1986, training report which showed "there were no hot drills conducted at all," Mr O'Bray stated that calls were made to the airport fire chief and the airport manager suggesting to them that funding restrictions should not have been a problem because funds had been allocated (Transcript, vol. 35, p. 69). When asked what their response was, Mr O'Bray stated in testimony that:

> A. Mr Parry's response specifically was that they were operating on a global budget and that the funds could be allocated to other airport operations.
> Q. And I take it you disagreed with them?
> A. Yes, sir, I did.
>
> (Transcript, vol. 35, p. 69)

Because Mr O'Bray was concerned about the position taken in the training reports regarding funding restrictions, he made inquiries with Central Region's community airports officers and was advised that, as far as they were aware, the funds were available and that the Dryden airport had the funds to conduct CFR training.

The position taken by Chief Parry was not an isolated occurrence. On October 10, 1989, seven months after the crash of C-FONF, Central Region emergency services officers Jack Nicholson and Jeffrey Hamilton conducted a site evaluation of the Dryden CFR unit. In addition, Mr Hamilton testified that they also wanted to know why the CFR training program was not being carried out. Upon their arrival at the Dryden airport, the emergency services officers met with Chief Parry, the acting airport manager at the time. During the meeting, Chief Parry was asked why he was not spending the allocated training funds to purchase fuel for fire-fighting training, and Mr Hamilton testified as follows:

> A. ... Mr Parry told Mr Nicholson that there wasn't any money spent on fuel or the money that was allocated was not spent on fuel and that he was not intending to spend it that he didn't have to spend it, on training fuel.
>
> (Transcript, vol. 33, p. 202)

Mr Hamilton stated during testimony that he was left with two clear impressions: Chief Parry did not want to conduct the training and Chief Parry was quite confident that he could take money allocated for CFR training and spend it on other airport operations. The October 1989 site visit was Mr Hamilton's first to the Dryden airport CFR unit, and he

disagreed with the position taken by Chief Parry.

The testimony indicates that, as early as 1986, Mr Louttit and Chief Parry were either not spending funds allocated for CFR fire training or were using the funds for other airport expenses. This situation continued after the crash of C-FONF and the commencement of the work of this Commission of Inquiry, as is evident from the October 1989 evaluation.

Ms Paulette Theberge, Transport Canada Central Region's financial officer responsible for dealing with the Dryden Municipal Airport and the Dryden Airport Commission, gave evidence that funds for fuel and extinguishing agent for training are specifically allocated in the annual budgets. For example, in 1988, Dryden submitted a $30,000 budget request for fuel for fire drills and for extinguishing agent. After negotiations with Transport Canada, the authorized allocation was $17,500; however, the actual amount spent was $5088. She had no information on how the remaining money was spent. Ms Theberge agreed that it would appear that over $12,000, allocated for CFR training fuel and extinguishing agent, was spent on other needs at the airport. Ms Theberge also agreed that there was no justifiable reason for the fire chief and the airport manager to use training funds to accommodate shortfalls in the overall budget (Transcript, vol. 36, p. 203).

Superintendent O'Bray testified that he spoke to the financial assistance officers and community airports officers within Transport Canada and was advised that funds were available for training. However, he did not specifically request that these officers require Mr Louttit and Chief Parry to use the allocated funds for training. When asked why he did not request that these Transport Canada officers enforce proper use of the allocated funds, Mr O'Bray replied as follows:

> A. Perhaps – it was always our philosophy to go to the ... what we perceived at that time to be the line managers of those airports. But as we were finding out throughout that period ... they did not have line authority over these airport[s] either.
>
> Q. So the Community Airports people who were basically in the same region did not have line authority over the community airports – or subsidized airports?
>
> A. That was my understanding, yes.
>
> (Transcript, vol. 35, p. 70)

Mr O'Bray also agreed in testimony that he was "getting messages" from senior managers in Airports Authority Group, Ottawa, regarding the lack of enforceability of AK standards on subsidized airports.

Transport Canada–Subsidized Airport Policy

Testimony at the Commission hearings demonstrated that Transport

Canada personnel were unable to persuade or to force the Dryden airport management to train their CFR unit fire-fighters to a level of proficiency they believed satisfactory. The evidence is equally clear that Dryden airport management, and in particular Chief Parry, did not ensure that the Dryden airport CFR unit fire-fighters received sufficient training to enable them to carry out their duties and responsibilities as CFR fire-fighters adequately.

During the summer and fall of 1986, the Program Control Board (PCB) of Transport Canada advised the then executive director, Airports Group, Mr David McAree, that no additional funds would be forthcoming for subsidized airports. Accordingly, Mr McAree, the senior Transport Canada officer responsible for the operation of Canadian airports, by memorandum dated October 3, 1986, entitled Grants and Contributions to Subsidized Airports, passed that information to the regions and instructed them to deal with subsidized airports as follows:

> Therefore, it is imperative that negotiations be hard and tough to control costs; that standards are to be re-examined and local airports allowed more flexibility and freedom to manage. In addition, revenue-generating opportunities should be emphasized.
>
> To this end, it is recognized that subsidy airports may find it necessary to deviate from standards in effect at departmentally-operated airports. However, in no case can safety and security standards be allowed to be compromised.
>
> (Exhibit 279)

At the same time, the Airports Group was advising subsidized airports that, because of budget restraints, Transport Canada would allow standards to be relaxed, since subsidized airports would not be receiving all the funds they might need to maintain their airports at those standards; however, safety and security standards could not be compromised.

Various regions began asking Airports Group headquarters for clarification regarding the standards that subsidized airports were required to meet. The original request for clarification came from Pacific Region. Mr McAree responded to all regions, in a memorandum of October 20, 1986:

> Due to present and future funding limitations and legal opinions rendered, it has been decided that we should not concern ourselves with the day-to-day operations at subsidy airports per se, except as affected by:
>
> a) Safety and security
> b) Airside – regulations
> c) Groundside – value for money

> AK documents are considered to be Transport Canada policy-related documents, and as such, cannot legally be imposed on subsidy airports except in those cases where the AK documents are given effect or incorporated in relevant regulations, or have been specified within the lease/agreement document prior to signature by both parties.
>
> Although it is desirable that the subsidy airports meet Transport Canada standards, it is recognized that they may find it necessary to deviate from AK standards applicable at Transport Canada operated airports. However, in no case can safety and security standards be allowed to be compromised.
>
> PCB has directed that standards are to be re-examined and local airports allowed more freedom to manage; that we encourage local flexibility in such matters as non-safety standards and landing and terminal fees. Please also refer to my 3 October 1986 memorandum providing your 1987/88 Preliminary Reference Level.
>
> AK documents can continue to be provided to subsidy airports as information and guidance tools.
>
> (Exhibit 280)

These two memoranda provided instructions that looser control was to be exercised over subsidized airports and that managers of those airports were not bound by the standards specified in Transport Canada AK policy documents, with the exception of safety and security, aviation regulation, and value for money. At least in Central Region, emergency services officers questioned whether subsidized airports could deviate from the requirements of AK documents regarding CFR standards and training.

It was the view of emergency services officers Nicholson and O'Bray that, if funds were allocated for CFR training, they must be spent on CFR training. In the words of Mr O'Bray, "there was a lot of confusion in almost everyone's mind of whether, with respect to the documents that were coming down talking about safety and security, of whether CFR was a safety issue or a level of service" (Transcript, vol. 35, p. 79). Mr O'Bray stated that, within his branch, Mr Nicholson considered that CFR was a safety issue and that Transport Canada should be firm and require training levels to be maintained at subsidized airports at a level satisfactory to Transport Canada. Mr O'Bray testified that he was of the same view. However, direction received from senior management levels in Transport Canada headquarters and the position taken by the Transport Canada Community Airports Branch indicated that CFR was not a safety issue but a level of service. Mr O'Bray's impression was that both Transport Canada headquarters and Community Airports Branch agreed that, because CFR was not a safety issue, subsidized airports could deviate from CFR training requirements.

It is apparent that, as part of the effort by Transport Canada to reduce the cost of subsidizing airport operations, Airports Group lumped AK CFR standards with other airport AK standards. This created a situation where subsidized airports could deviate from required CFR training standards.

On behalf of his superior, H.J. Bell, Mr O'Bray prepared a memorandum to the executive director, Mr McAree, requesting clarification of the situation regarding CFR standards. The message, designated GRDG 3 145 and dated November 7, 1986, is as follows:

> RE: EDA MEMO A5172-1 OF OCTOBER 20, 1986
> SUBJECT: APPLICABILITY OF AK'S TO SUBSIDIZED AIRPORTS.
> PLEASE CONFIRM THAT CFR IS A LEVEL OF SERVICE ISSUE AND IS NOT CONSIDERED A SAFETY ISSUE IN TERMS OF COMPROMISATION OF AK'S. YOUR CONFIRMATION WILL ASSIST US TO DEVELOP A CONSISTENT LEVEL OF SERVICE AT SUBSIDIZED AI[R]PORTS EQUIVALENT TO I.C.A.O. STANDARDS.
> H. J. BELL
> CRDG
>
> (Exhibit 281)

Mr McAree responded on December 1, 1986, sending copies to all regions. His response was as follows:

> REFERENCE IS MADE TO CRDG MESSAGE NO. 145 DATED 7 NOVEMBER RE. APPLICABILITY OF AKS TO SUBSIDIZED AIRPORTS. LEASE OF AIRPORT TO MUNICIPALITIES ENTITLED LESSEE TO QUIET ENJOYMENT WITH COMMITMENT TO MAINTAIN AIRPORT AS PUBLIC AIRPORT TO LICENSABLE STANDARDS AND TO CHARGE FEES NOT LESS THAN THOSE CONTAINED IN AIR SERVICES FEES REGULATIONS. THEREFORE CFR SERVICES ARE NOT MANDATORY AND SHOULD BE DETAILED IN APPROPRIATE AERONAUTICAL PUBLICATIONS. AKS ARE AVAILABLE TO MUNICIPAL SUBSIDIZED AIRPORTS FOR GUIDANCE PURPOSES ONLY.
>
> (Exhibit 282)

Since both Mr O'Bray and Mr Nicholson were of the view that CFR was a safety issue, the memorandum signed by Mr Bell did not truly reflect their views. It appears that Mr Bell only wanted confirmation from Mr McAree that CFR was a level of service without a safety component and, therefore, AK standards need not be followed at subsidized airports. The first message did not ask the right question and the second message avoided any reference to the level of service–safety issue raised by Mr Bell, and declared that CFR services are not mandatory at subsidized airports.

Mr McAree's December 1, 1986, response is similarly ambiguous. As Mr McAree did not appear before this Commission, I will not speculate as to his intentions in providing such a message. Mr O'Bray stated during testimony that it was obvious to him that the question that had been asked was not specifically answered.

Even though Mr O'Bray's concern had not been addressed by Mr McAree, Mr O'Bray testified that he was not about to ask for further clarification "given the fact that it was not customary to ask Mr McAree the same question twice" (Transcript, vol. 35, p. 86).

What is clear, however, is that no further effort was made by Central Region to clarify the meaning of the message contained in the statement, "CFR services are not mandatory and should be detailed in appropriate aeronautical publications." Clearly clarification of this instruction should have been sought from headquarters by Central Region if they were not satisfied that the instructions were unequivocal. In view of Central Region's knowledge of lack of training by the Dryden CFR unit and the impression being conveyed by Transport Canada headquarters that CFR units at subsidized airports did not have to train to Transport Canada standards, Central Region should have instructed the Dryden Municipal Airport Commission to publish, in the *Canada Flight Supplement*, a notification that Transport Canada CFR training standards were not being met at the Dryden airport. I find that Transport Canada should have but did not take action either to enforce training standards or to have airport users notified that training standards were not being met.

The evidence is clear that Transport Canada, faced with budget restraints, instructed regions to negotiate "hard and tough" regarding budget requests made by subsidized airports. Transport Canada headquarters also gave instructions to regions to allow managers of subsidized airports to deviate from Transport Canada AK document standards when it came to maintaining and operating their airports.

On December 22, 1986, Mr H.J. Bell sent a letter to Mr W.F. Beatty, the chairman of the Dryden Municipal Airport Commission, providing Transport Canada's view on deviation from standards. Part of the letter reads as follows:

> Relative to our discussions regarding airport standards, you are advised that although desirable, Transport Canada standards cannot legally be imposed upon leased airports, excepting for those matters affecting safety, security and certification requirements. Our AK documents may however continue to serve as information and guidance tools. Further, our Program Control Board directs that Transport Canada encourage more flexibility and freedom to manage among local (leased) airport administrations.
>
> With specific reference to the provision of crash, fire, rescue services (CFR); again this service is not mandatory at leased airports.

> Your administration is free therefore to maintain that service to a level commensurate with funding levels available, in consideration of overall airport functions. As an example, it may be appropriate, given an adjustment of your hours of operation, etc., to staff a CFR nucleus of a Fire Chief plus one Firefighter, around which auxiliary support may be established, thus providing a capability comparable with that provided at The Pas, and proposed at Churchill Airport.
> (Exhibit 91)

Internal Transport Canada directives and correspondence to the Dryden Municipal Airport Commission clearly indicated, to both the Transport Canada regional employees and the Dryden airport managers, that subsidized airports could deviate from AK standards, which included standards dealing with CFR, and that funds allocated for CFR purposes could be applied to other airport expenses. Although Mr O'Bray may have disagreed with the position taken by Mr McAree, he accepted Mr McAree's directive and, accordingly, he should have acted on its instructions. As the Community Airports Branch also received similar instructions, Mr O'Bray would receive no assistance from them.

From the evidence, it was obvious that Mr Louttit and Chief Parry believed they did not have to comply with AK CFR standards, and they considered that funds designated for CFR training could be used elsewhere to cushion the effects of the decreasing airport subsidy.

Enforceability of Agreements

I will now turn to Mr McAree's memorandum of October 20, 1986, wherein he states, in part, the following:

> ... AK documents cannot legally be imposed on subsidy airports except in those cases where the AK documents are given effect or incorporated in relevant regulations, or have been specified within the lease/agreement document prior to signature by both parties.
> (Exhibit 280)

Ms Theberge testified that, in her opinion, the Dryden Municipal Airport had to provide airport services, including CFR services, to the satisfaction of the minister. It was also her opinion that CFR, as an airport service, falls under the terms and conditions of the financial assistance agreement between Transport Canada and the Town of Dryden. Clauses 7 and 12 of the agreement state as follows:

> 7. *Ministerial Approval*
> The Corporation shall not, without the consent in writing of the Minister, being first had and obtained, assume any obligations

> or make any expenditures under the provisions of this Agreement which is not in accordance with annual operating budgets approved by the Minister.
>
> 12. *Corporation Provision of Facilities*
> ... the Corporation shall be responsible for the operation, management and maintenance of the Airport, and all related facilities which, without limiting or restricting the generality of the foregoing, shall include airport services, runways, fences, hangars, shops, terminal and other buildings, airport lighting equipment, and like services, and the Airport shall be maintained in a serviceable condition, all to the satisfaction of the Minister.
>
> (Exhibit 288)

Ms Theberge also referred to the airport lease agreement which, in her view, also obligated the Town of Dryden as a lessee to maintain CFR services to the satisfaction of Transport Canada.

Clause 8 of the lease agreement states as follows:

> That the Lessee shall at all times during the currency of this Lease, operate, manage and maintain the said airport, and all related facilities which, without restricting the generality of the foregoing, shall include airport services, runways and taxiways, fences, buildings, airport lighting facilities, airport maintenance, equipment and like services, all herein referred to as "the said facilities," all as designated by and to the satisfaction of the Administrator and at the expense of the Lessee.
>
> (Exhibit 27)

It was Ms Theberge's opinion that if the CFR services provided at the Dryden airport did not satisfy Transport Canada, then the Town of Dryden would be in violation of both the subsidy agreement and the lease agreement.

While not specific in referring to CFR services in clauses 12 and 8 of the respective agreements, both the airport subsidy agreement and the lease agreement in effect on March 10, 1989, required the Town of Dryden to operate and maintain the airport and all related facilities, including airport services, to the satisfaction of the minister of transport. I agree with Ms Theberge. I interpret the agreements, and specifically the following wording within the agreements, "without limiting or restricting the generality of the foregoing," "all related facilities," and "airport services," to be broad enough to include CFR services.

The airport subsidy agreement and the lease agreement are general in nature. However, without specific direction to a subsidized airport to the contrary, I interpret the intent of the statements "to the satisfaction of

the Minister" and "to the satisfaction of the administrator" to mean that Transport Canada intended to impose upon subsidy airports, to their fullest extent and in the same manner as it does upon Transport Canada – operated airports, AK document standards, including CFR training requirements.

In summary, I disagree with Mr McAree's view that AK documents cannot legally be imposed upon subsidy airports. The intent of both clause 12 in the airport subsidy agreement and clause 8 in the lease agreement is that they contemplate standards satisfactory to the minister. As the standards of Transport Canada are the internal Transport Canada AK policy documents, these same standards are those to which subsidized airports must adhere unless otherwise advised.

In addition, clause 7 of the subsidy agreement provides that the Town of Dryden cannot, without the consent of Transport Canada, make any expenditures under the subsidy agreement that are not in accordance with annual operating budgets approved by Transport Canada. It follows that, if the airport manager wanted to use funds allocated for CFR training for other airport expenses, he could only do so with the express consent of Transport Canada. No such approval was given.

It is clear, however, from the memoranda and messages signed by Mr McAree and from Mr Bell's letter to the Dryden Municipal Airport Commission, that Transport Canada was prepared to allow subsidized airports to deviate from Transport Canada AK standards with certain exceptions. This was in keeping with the government's policy of fiscal restraint and specific instructions by the Program Control Board (PCB) to various senior managers. Mr McAree's instructions to negotiate "hard and tough to control costs" and to re-examine standards to allow local airports "more flexibility and freedom to manage" were designed to relieve the pressure upon Airports Group to provide additional funds to subsidized airports under their grants and contributions program. However, Mr McAree also advised the regions that in no case can safety and security standards be allowed to be compromised.

CFR Services: The Issue of Safety

Two issues must be considered: did Transport Canada intend to allow subsidized airports to deviate from Transport Canada's required CFR training standards; and, do CFR units provide a level of safety at airports? During the hearings, in attempting to determine why Dryden airport managers refused to train their fire-fighters to the same standards as at Transport Canada–owned and operated airports, considerable testimony dealt with the safety component of CFR services. It was the testimony of Mr Nicholson that, when he confronted Chief Parry for not using funds as allocated for fire-fighter live-fire (hot-drill) training, Chief Parry referred to Mr Bell's correspondence to the Dryden airport

commission as his authority for not being obligated to train his men to Transport Canada AK standards. This discussion took place between Chief Parry and Mr Nicholson in October 1989 at a time when Chief Parry was not only the chief of CFR services but also the acting airport manager.

It was the view of Mr Nicholson that the training of CFR fire-fighters is a safety-related operation and that Chief Parry was obligated to comply with Transport Canada standards in terms of maintaining a fire-fighter's level of knowledge and proficiency in carrying out his duties.

Mr McAree in his message of December 1, 1986, stated that CFR services are not mandatory and that AKs are available to municipal subsidized airports for guidance purposes only. Mr Bell, in his letter to the Dryden Municipal Airport Commission, advised that the airport commission was free to maintain the CFR service to a level commensurate with funding levels available, in consideration of overall airport functions, and suggested ways this might be done. He suggested that it might be appropriate to adjust the hours of CFR operation, and/or to decrease the professional fire-fighting staff to a nucleus of a fire chief plus one fire-fighter and establishing an auxiliary fire-fighting team.

While Mr McAree's message is ambiguous, I do not find the position of Mr Bell in conflict with the view of Mr Nicholson that training standards of fire-fighters must be maintained to Transport Canada AK standards. While Mr Bell suggested decreasing the number of professional fire-fighters and augmenting them with auxiliaries, he did not recommend that they need not train to AK standards. Specific funds for the purchase of training materials for CFR fire-fighters were allocated in the Dryden airport budget. Training was always contemplated and, therefore, funds for training were always allocated in the budgets no matter what funding level was available. While Mr McAree's instructions were unclear, I cannot believe and do not find that it was the intention of Transport Canada to allow subsidized airports to deviate from Transport Canada's CFR training standards.

Whether CFR is a level of service or a level of safety is an important issue. It is readily apparent to me that a CFR unit is established at an airport for one reason, to provide a level of safety with regard to aircraft crashes and aircraft fires. Therefore, once the CFR unit is established, the fire-fighters of that unit must know exactly what is expected of them and be capable of effectively and efficiently operating their fire-fighting equipment. It makes no sense that expensive and sophisticated fire-fighting equipment sat on the sidelines on March 10, 1989, because the CFR fire-fighters, for lack of adequate training, did not use their equipment in carrying out the primary and secondary objectives of CFR, that is, saving lives by providing a fire-free escape route and preserving the property involved by containing or extinguishing the fire. Two of the

three professional CFR fire-fighters, as well as the volunteer fire-fighters of the UT of O, carried out some of the tasks that could have been handled by untrained rescuers, such as the assistance rendered to surviving passengers after they had arrived at a safe distance from the fire.

The fact that the CFR fire-fighters at the Dryden airport were not properly trained is the fault of the entire system. The Dryden airport managers avoided the training requirements. Transport Canada headquarters personnel were too far removed from the problem to appreciate fully the difficulties resulting from the lack of clear direction with regard to CFR training. Although Transport Canada regional personnel attempted to persuade Dryden airport staff to conduct the required training, and although the CFR crew chiefs may have espoused that they wanted training, no one made a concerted effort to see that meaningful training was accomplished. In sum, it is my opinion that no one was sufficiently serious about CFR.

In his Report of the Commission of Inquiry on Aviation Safety of 1982, Mr Justice Charles L. Dubin discussed airport emergency services (AES). In this report, the Public Service Alliance of Canada is quoted as stating the following: "Firefighting is a profession – not something to be carried out in a haphazard manner by untrained personnel."[4] I totally agree with this statement.

In delineating the responsibilities of AES (CFR) personnel, Mr Justice Dubin stated that "it is not the AES responsibility to care for the injured after they have arrived at a safe distance from the accident site" (vol. 3, p. 973). I also agree with this view. Once aircraft occupants are removed to a safe distance from the accident site, fire-fighters should be left to their role of fighting the fire, preserving the wreckage, and securing the area from any further danger. Finally, in his comments regarding the role of AES (CFR) services, Mr Justice Dubin stated: "The emergency services personnel are an integral part of the overall safety system" (p. 975). I cannot state the role of CFR services more clearly.

The above comments and observations made in Mr Justice Dubin's report clearly echo my own views, and those of the experts who appeared before me, on the duties, responsibilities, roles, and training of CFR services personnel. Had the fact that CFR services are an integral part of the overall safety system been recognized by Transport Canada and had the message been clearly conveyed to the Dryden Municipal Airport that fire-fighting training must be conducted properly, I might not have needed to review in such detail the actions of and response by the Dryden Municipal Airport CFR services unit to the crash of C-FONF.

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[4] *Report of the Commission of Inquiry on Aviation Safety*, 3 vols. (Ottawa, 1981–82), vol. 3, p. 972

CFR Assessment by Transport Canada and Dryden Authorities

On the day of the crash, Mr Desmond Risto of Transport Canada, Airports Authority Group, Central Region, went to Dryden to provide assistance and encouragement where he could to the Dryden airport staff, and the airport commission was so advised. An emergency services officer, Mr Jack Nicholson, was also dispatched by Central Region two days later to determine what the Dryden airport CFR unit had done in response to the crash. Both Mr Risto and Mr Nicholson prepared reports that were sent to Mr George Knox, the acting regional director-general, Airports Authority Group, Winnipeg.

During their visits, Mr Risto and Mr Nicholson were briefed by CFR Chief Ernest Parry and by crew chief Stanley Kruger regarding the response of the CFR unit to the crash. In their reports, Mr Risto and Mr Nicholson summarized the circumstances leading up to the crash and discussed the subsequent activities of personnel of the CFR unit, the UT of O fire unit, and the OPP.

On page 5 of his report, Mr Risto praised Chief Parry for his actions as follows:

> Within a space of seconds, AFC [airport fire chief] decided to take on the responsibilities of On-Scene Co-Ordinator (O.S.C.), rather than abandon his vehicle and respond to the crash scene for fire suppression. Had this <u>correct</u> decision not been made, immediate multiple communications, direction and requests would have been lost, and complete chaos would have ensued pending the arrival of support agencies and equipment.
>
> Because of the correct position taken by the AFC, and direction applied, there is no question that a systematic and organized rescue operation was conducted as response personnel were given positive and immediate instructions, with main arteries being kept open until the arrival of the O.P.P. Again, because of the correct action being taken, there is no doubt in the minds of the airport staff that more casualties/passengers were saved.
>
> (Exhibit 237)

In reporting on the CFR unit response generally, Mr Risto stated that because of the snow depth and heavily treed area between the access road and the crash site, it was impossible for one to three men to pull a handline to the crash site. However, it would not have been necessary to pull a handline to the crash site because lengths of hose could have been connected in sequence. In addressing the mechanical breakdown

of the CFR unit vehicle Red 2, Mr Risto considered that use of the CFR unit fire trucks was "irrelevant" because of the conditions.

Mr Risto stated in his report that the response of the UT of O Fire Department was exceptional, and he remarked on the speed at which the UT of O Fire Department arrived on the scene and set up the water tank and foam equipment. Again, Mr Risto commented that it was impossible to drag 400 feet of hose through the terrain until a trail was cut to the crash site.

On March 16, 1989, the Town of Dryden and Transport Canada held a debriefing session in Dryden to discuss any major problems and concerns that arose out of the implementation of the Town of Dryden's Peacetime Emergency Plan. Mr Risto's report on the debriefing is short and touches briefly only on the need for a better communications network and the need to upgrade existing resources and inventory.

Based upon his experience as Central Region coordinator for emergency and disaster planning, Mr Risto could see nothing "flagrant or critical done out of context with established procedures and *common sense*."

Mr Nicholson in his report of March 22, 1989, summarized the activities of the Dryden Airport CFR services unit in responding to the crash. Mr Nicholson reviewed its actions, summarized the circumstances of Red 2 having to fill up with water, Mr Rivard losing control of the vehicle, and the loss of the air brake system in the vehicle. After describing the actions of the CFR fire-fighters, Mr Nicholson concluded in his report that in his judgement the CFR crash vehicles could never have "dozed" their way to the crash site. He also stated that Red 2 carried only 300 feet of 1½ inch hose line and Red 1 had 100 feet of unusable handline. The information that Mr Nicholson obtained from Chief Parry regarding Red 2 was incorrect. Red 2 actually carried 500 feet of handline. Mr Nicholson concluded that the CFR fire chief and crew could be commended for "the conscientiousness and professionalism shown during the events leading up to and attending the crash incident."

The Dryden CFR crew chiefs, Stanley Kruger and Bernard Richter, provided observations and suggestions to their fire chief and to the airport manager regarding the CFR response to the crash. These observations and suggestions in my view were well conceived and, accordingly, I quote their entire submission to their superiors:

Observations and Suggestions of Dryden CFR Crew

March 13, 1989

Better call in system, steps should be taken to ensure all CFR personal is called in for any and all significant emergency response.

Paging system could be activated to help with the problem of contacting personal.

Better maintain access roads to runway, road from firehall to the runway should be kept sanded on a priority basis in winter months. Access roads at the end of the runway at each end should be kept open in winter months.

Trucks should be maintained to peak conditions regardless of cost, or replaced.

Transport Canada should be made aware or the need to reevaluate policy of only one man per truck, especially at northern airports. Due to the depth of snow and rugged terrain experienced in the north it does not seem reasonable to expect one fireman one truck to do a proper job of rescue, firefighting, and/or saving possible evidence under these conditions. Even two men in one truck and one in the second would be a major improvement.

We should align ourselves more closely with Transport Canada so we can receive similar benefits re information and training.

Should try and make sure there is a town pumper to provide fire protection if airport operations continue during an emergency.

CFR personal directly involved in a disaster should continue to be involved as much as possible in the days following the incident if they wish so they do not feel they had to leave the job unfinished. There should also be an optional debriefing if possible within twenty-four hours.

The above are observations resulting from discussion among CFR crews following the crash of Air Ontario's F28 March 10, 1989 in Dryden. These are made in hopes of benefiting future operations of CFR, and is in no way, nor is it meant to be, a criticism of any person, department or organization.

(Exhibit 186)

On April 12, 1989, the Dryden airport manager, Mr Peter Louttit, forwarded a report of the F-28 accident to Transport Canada. The report was submitted as an Emergency Exercise Report, presumably fulfilling an exercise requirement. The report dealt with the response by the airport and its CFR unit to the crash. There were five specific deficiencies identified regarding the response by the CFR unit as follows:

1. There was no formal alarm given. CFR were made aware by witnesses waving and yelling.
2. Town dispatcher and others did not recognize the magnitude of the situation from only being given the aircraft model i.e. "F-28 crash." Need to be more specific for non-aviation personnel.
3. CFR vehicles could not reach site due to snow depth and dense bush. Firefighting was done with handline from a fire pumper truck.
4. The CFR call-in system for calling in off-duty personnel didn't work. Needs to be replaced with a better system.

5. Supply of blankets in CFR firehall could not be located by non-CFR persons sent for them. (Boxes have since been marked)

(Exhibit 240)

The report, after identifying problems encountered during the crash, suggests solutions. One of the solutions was to add a pumper truck to the CFR fleet. The report lists other salient points learned from the emergency as follows:

1. CFR tactics, equipment, and manning standards need to be re-examined for sites such as Dryden that are surrounded by heavy bush, rough and/or swampy terrain, and heavy snow falls in the winter.
2. The On Site Coordinator is too busy with the logistics and priorities of the emergency to keep written records of events in chronological order. Some means of tape recording his activities and the time intervals is required.

(Exhibit 240)

Mr Louttit's report of April 12, 1989, did not include all the observations and suggestions of the Dryden CFR crew chiefs. In particular, he did not comment on deficiencies they observed, such as maintenance of access roads to the runway, maintenance of the fire vehicles, re-evaluation of Transport Canada policy regarding personnel and vehicles, and alignment of Dryden airport policies closer to those of Transport Canada so that the Dryden CFR fire-fighters could receive better information and training. In my view, Mr Louttit's report should have included all these observations.

Although both Mr Risto and Mr Nicholson were quick to praise the response of the CFR fire-fighters, neither of their reports analysed deficiencies in the CFR response so that the Dryden Municipal Airport and Transport Canada could correct the deficiencies. It was not until both Mr Risto and Mr Hamilton testified before me that they confirmed that the CFR unit had made a number of errors in its response to the crash.

While it was the intention of Transport Canada to provide assistance and encouragement to the Dryden airport staff, it is my view that they should have investigated the response of the CFR unit more thoroughly to determine if there were inadequacies in the response. Because Transport Canada did not analyse the response rigorously and because the airport manager and the fire chief did not provide to Transport Canada their own thorough critique, a true picture of the CFR response was not available to the Dryden Airport Commission or to Transport Canada.

Mr Henry Moore was, at material times, the director, Airports Safety Services, Airports Authority Group, Transport Canada headquarters, and, as such, was responsible for standards and training for CFR services. During his testimony before this Commission, he was asked if there was any existing mechanism whereby Transport Canada CFR experts participated with Transportation Safety Board of Canada (TSB) investigators to assess the response of a CFR unit to a crash. Mr Moore stated that Transport Canada does not have a formal procedure either internally or with the TSB to review the response of a CFR unit to a crash. Although Transport Canada emergency services personnel are normally asked to visit an accident site immediately to assess CFR actions, no procedure exists to evaluate a CFR unit's response to a crash.

Mr Moore testified that his branch carefully followed this Commission's hearings to determine what lessons could be learned with regard to CFR and what information could assist his headquarters branch. I deal with Mr Moore's response to the hearings under the section in this chapter titled Observations. However, I deem it important to quote part of Mr Moore's testimony as an example of how Transport Canada has responded to deficiencies revealed during these hearings. When asked what lessons Transport Canada had learned and what sort of information had been obtained, Mr Moore stated as follows:

> A. I decided to become quite involved in [the] ... hearings of the Commission because we don't very often have – thank God ... crashes or serious accidents in aviation, and, just for the very purposes that you outlined, I wanted to follow it as very closely as an individual.
>
> And I have attended most of the hearings, the majority of the hearings, I believe, and it has certainly raised the degree of urgency, if I can use that type of terminology, both for myself and for my staff.
>
> Without prejudice and without making any assumptions in terms of the status, whether or not CFR services were being provided well at other airports, I sort of took the approach, if that sort of thing could happen at Dryden, there's a possibility it could happen somewhere else and how should we prepare to deal with that type of an incident should it occur.
>
> A couple of things became apparent to me early in the exercise. One was the need ... to ensure that we had adequate crash charts available. In August of last year, I had my staff conduct a survey to determine the adequacy and the availability of crash charts on a national basis.
>
> Based on that survey, we decided that we weren't as well prepared there as we felt we should be ... back in November, then, we went out again with a stronger memo saying that you – essentially, get those crash charts and have them available.

Then it was sometime after that the question was raised here at the hearings, and, since that time, we've decided to take a very strong position in this case here, and our approach is going to be to ensure that, when new aircraft ... receive type approval for operations in Canada, part of that package is going to be to provide us with crash charts, and we're going to distribute them from our headquarters. And my people evaluate the availability when they visit airports, so I don't want any more problems with crash charts.

Q. So that's a positive step in the right direction, obviously?

A. Yes.

...

A. A second thing, very early in the exercise, my assessment of what happened, based on the testimony at the scene and in consultation with members of my staff, we felt that we were going to have to do something to emphasize further the need for a strong, well-trained and knowledgeable on-scene commander.

And I have given instructions to my people to proceed with developing such a training course, and we should have that in the new year.

A number of other programs, without any specific written direction from me, but just the general sense of urgency, that we had better get on with some of these things, to the best of our ability, I feel that ... as an example, the FR Certification Program was accelerated.

I made the decision to distribute all of the documentation for this training program probably in the July – August time frame, in that area, with advice to the people affected that the specific instructions as to how the documentation was to be used would be forthcoming.

In other words, we had all the documentation, but the specific administration of the program hadn't been finalized. But we said, here is the documentation, you fellows start taking a look at it, you start using it, start becoming familiar with it, critique it, come back to us, specific instructions will be forthcoming. And they were in fact forthcoming, and the program had an official start date of November 1.

Q. And so you have accelerated the program by, what, two or three or four months?

A. Probably a couple of months, right.

(Transcript, vol. 38, pp. 26–29)

Mr Moore, in the above-quoted testimony, cited a few examples of where Transport Canada has responded positively to the evidence on CFR that unfolded during the Inquiry hearings. These and other responses are listed in the Observations section below. I commend the positive effort taken by Transport Canada regarding actions which I agree are appropriate in dealing with obvious deficiencies in the aircraft

crash response system. However, in order to assist both the responding unit, other CFR units, and Transport Canada in improving CFR capabilities, I recommend that, whenever a CFR unit responds to an aircraft crash, Transport Canada, as part of its post-crash response, immediately analyse the actions of the CFR unit. It is important that all the CFR actions be reported on so innovative ideas can be discussed, deficiencies in the response can be corrected, and useful information, both positive and negative, can be passed to other CFR units.

Observations

I have paid particular attention to the matter of crash, fire-fighting, and rescue services not only because of the involvement of and response by the Dryden CFR unit but also because of the need to recognize its importance as part of the overall safety net at airports where air carriers operate on a frequent and regular basis. As a result of the testimony that was heard before this Commission, Transport Canada has responded to deficiencies exposed in a positive manner prior to the issuance of this my Final Report.

While I have deemed it necessary to identify the errors that were made by the Dryden CFR unit, I also wish to recognize those actions taken by Transport Canada to correct the CFR shortcomings uncovered during this Inquiry. I deem it appropriate to list in its entirety a letter from Mr Moore, dated March 13, 1991, addressed to Senior General Counsel, Department of Justice, Canada. A copy of this letter was provided to me for my review and consideration. Action taken by Transport Canada as outlined by Mr Moore is as follows:

> Item 1 – Aircraft Crash Charts
>
> Every effort has been made during the past year to ensure that airports have the requisite crash charts. We are confident that the availability of crash charts at Transport Canada owned and operated airports has never been better. As a separate thrust, we concluded a letter of agreement with the ADM – Aviation Group that led to Policy Letter No. 49. This policy provides for a means of ensuring the provision of pertinent crash charts concurrent with the introduction of new aircraft types into regular service. My staff are also engaged in the final production of a crash chart manual, which will include over 260 different types of commercial aircraft. This document will be distributed in sufficient quantities so as to provide for one manual to be placed in each crash truck in the system. In addition, a second manual in larger-size format will be provided to each fire hall and Emergency Co-ordination Centre for quick

reference and training purposes. This latter project has been extremely demanding because of the need to rework numerous charts to provide for standardized drawings. The results have been well worthwhile, and the first printing should be distributed during the next two or three months.

Attachments:
Appendix A – Letter of Agreement, dated June 1990
Appendix B – Policy Letter #49

Item 2 – On-Scene Controller Training

Our approach to developing the documentation for this training course was predicated on the need to act quickly. Briefly, the first training course was presented to key personnel at the Transport Canada Training Institute (TCTI) during November of 1990. The course participants then returned to their respective Airports or Regional Headquarters to present the training to employees within their areas of responsibility. In addition, the On-Scene Controllers Course will be incorporated into our on-going Disaster/Emergency Planning and Airport Duty Managers' courses. You will note that we have also chosen a new title "Controller" to better reflect the importance placed on this activity. Our program is on-schedule, and the results to date have been most gratifying.

Attachment:
Appendix C – AK Directive 1990-A0-20
On-Scene Controllers' Course
December 10, 1990

Item 3 – Safety Officer Certification Training

The development and presentation of this training is right on schedule. The first regular two-week certification course was presented at the Transport Canada Training Institute in March of 1990. Additional courses took place during September 1990 and February 1991. This is now an on-going program.

Item 4 – Critical Incident Stress Debriefing (CISD) –

This refers to my undertaking to address the matter of post-accident counselling for non-government firefighters at subsidized airports. This was discussed with the responsible Transport Canada officials on a number of occasions; however, a final determination has not been made in respect to this item.

Item 5 – Airport Fuelling Procedures

An AK Directive, dated March 22, 1990, was dispatched for the purpose of ensuring that the procedures established in TP 2231 (fuelling manual) were followed, and that the importance of this activity was clearly understood by managers on a national basis. TP 2231 was reviewed and revised in consultation with the Air Transport Association of Canada, and the new version was published in April of 1990.

Attachment:
Appendix D – AK Directive – Airport Fuelling Procedures, March 22, 1991*

Item 6 – Tracking of Firefighter Certification Program Training Progress

A computer program has been set up, and progress reports are being entered on a site-by-site basis to enable program implementation to be tracked by the Headquarters training officer.

Item 7 – All-Weather Training and Training on Difficult Terrain

A training committee review of this training indicated that the individual skills required of firefighters were already covered in the Firefighter Certification Training Program; however, it was also agreed that increased emphasis was in order. Additional Certification Program lesson plans were developed by specialists in this area and distributed to airports for review and comment. Final revised lesson plans are now ready for printing.

Item 8 – Snow-Clearing Access Roads/Crash Gates

A directive was forwarded to all affected Managers effectively instructing them to ensure that roads and gates are maintained clear of snow.

Attachment:
Appendix E – Snow Removal – Emergency Access Roads and Gates, March 23, 1990, File 5160-12-23 (AKOBC)

Item 9 – Emergency Response Services (formerly CFR) Evaluation Procedures

Revised evaluation checklists were developed for distribution to Airports for review, comments and guidance. Revised procedures were also developed to guide Headquarters staff during evaluations at Major Federal Airports.

Item 10 – Deletion of Water for Fuel Spills, etc.

Revised Certification Program lesson plans state that water must no longer be used to wash down a spill that is not contaminating a critical area.

Item 11 – Fire Officer Certification Program

This program is currently being developed. To date, working groups consisting of experienced Fire Chiefs and Fire Officers have completed the formulation of specific training objectives. The identification of requisite Fire Officer knowledge and skills has also been completed. We will now proceed with the preparation of detailed lesson plans. A parallel thrust is the development of a strategy for the delivery of the program. Consideration includes a number of centralized training courses complemented by on-site training. Formal training should get under way during 1991.

Item 12 – Primary Role of a Firefighter in Event of a Crash

The primary role of a firefighter is clearly identified in the Firefighter Certification Program; however, added emphasis has been place on this area at the Level I phase of the training program.

A number of other activities have also been under way, which can only serve to improve the response to any future incident that may occur at a Transport Canada Airport. Widespread circulation of selected Commission transcripts has taken place throughout the organization. A number of video tape recordings of key witnesses have also been distributed.

The details of the Dryden accident, as presented by Commission witnesses, have been discussed at many National and Regional conferences, meetings, seminars and safety-related training courses during the past year. We have no difficulty in suggesting that it would be almost impossible for any Airports Group employee,

associated with safety and/or emergency planning, to be untouched by the events of March 10, 1989.

Henry L. Moore
Director
Airport Safety Services

Attachments

The actions taken by Transport Canada listed above are all appropriate in dealing with the obvious deficiencies revealed as a result of this Inquiry. This positive effort by Transport Canada regarding aircraft crash responses should not end with the above actions but must be a dynamic process that continues beyond the term of this Commission of Inquiry.

Findings

- There is no legislation in the *Aeronautics Act*, Air Regulations, Air Navigation Orders, or any other Canadian legislation governing the requirements for CFR services at Canadian airports. Nor does legislation exist in Canada to compel a certificate holder of an airport not owned or operated by Transport Canada to comply with Transport Canada policy standards and guidelines regarding CFR services.

- The Dryden CFR unit personnel were not sufficiently trained to meet Transport Canada standards as set out in its AK policy documents.

- The Dryden airport manager, the CFR fire chief, the CFR crew chiefs, and the CFR fire-fighters did not ensure that all CFR personnel were trained in all aspects of crash, fire-fighting, and rescue as required by Transport Canada AK policy documents and as requested by Transport Canada emergency services officers on a continuing and regular basis.

- Budgeted funds from Transport Canada were allocated and available for the required training of the Dryden airport CFR personnel.

- The Dryden airport manager did not ensure that budgeted training funds were made available to the Dryden CFR unit. The budgeted training funds were diverted for use on other airport projects.

- Both the Dryden airport manager and the CFR fire chief incorrectly stated in training reports to Transport Canada that the reason hot-drill

fire training was not completed was because of the lack of funds, economic restraints, and funding cuts.

- Transport Canada personnel were unsuccessful in their attempts to persuade Dryden CFR personnel, directly and through the airport manager, to train properly.

- Both the lease agreement and the subsidy agreement between the Dryden Airport Commission and Transport Canada required that CFR services be maintained to the satisfaction of Transport Canada. The subsidy agreement required that variances in the expenditure of approved budget funds not be made without the expressed consent of Transport Canada.

- Transport Canada did not advise or warn the Dryden Airport Commission of the fact that proper CFR training at the Dryden airport was not being conducted. The lack of advice or warning was due in part to ambiguous direction given by Transport Canada Airports Group, Ottawa, to Transport Canada, Central Region, regarding the treatment of CFR units at subsidized airports.

- Communication between Transport Canada, Central Region's Safety and Services Branch, responsible for CFR services within that region, and the Community Airports Branch, responsible for the allocation of funds and the determination of budgets for subsidized airports, including the Dryden Municipal Airport, was deficient.

- Transport Canada, Central Region, Community Airports Branch, did not adequately monitor the spending of CFR training funds allocated to the Dryden Municipal Airport.

- Transport Canada, Central Region, Safety Services Branch, lacked vigilance and initiative in pursuing the fact that the fire chief and the airport manager did not ensure that adequate and proper CFR fire-fighting training was being carried out.

- The workload and responsibility placed upon one supervisor and two emergency services officers in Transport Canada, Central Region, was overwhelming in that they had the responsibility to train, evaluate, and supervise CFR units and to provide guidance and assistance to the airport managers and fire chiefs in Central Region, as well as assisting Transport Canada, Headquarters Emergency Services Division, in developing policy.

- The support provided by Transport Canada Airports Authority Group to the emergency services organization in Central Region was wholly inadequate.

- The Dryden CFR personnel were not familiar with the term CRFAA or its implications. This lack of familiarity with the CRFAA did not affect their response to the crash.

- AK-12-03-011, Transport Canada Crash Firefighting and Rescue Services Standards, is ambiguous when referring to "the CRFAA and the airport boundary," or "the CRFAA or the airport boundary," in that it is not clear whether these phrases are meant to include the entire CRFAA if its boundaries extend beyond the airport boundaries.

- The Dryden CFR personnel were not trained properly to deal with an aircraft accident on terrain inaccessible to fire-fighting vehicles.

- Transport Canada did not emphasize the use of extended handlines as part of the CFR training and evaluation programs.

- Transport Canada CFR policy documents are generally of a high standard.

- There was ample information in numerous documents available to CFR personnel and aircraft refuellers regarding precautions to be observed when hot refuelling.

- There was no information in manuals or documents normally available and used by Air Ontario F-28 pilots regarding hot refuelling.

- Aircraft refuellers at the Dryden airport did not follow correct hot-refuelling procedures.

- CFR personnel at the Dryden airport did not ensure that refuellers followed correct hot-refuelling procedures.

- Fire-fighting vehicles expended fire-fighting resources to clean up a small fuel spill when alternative means existed.

- Mr Vaughan Cochrane, contrary to ESSO instructions and Transport Canada documents, normally defeated the dead-man switch while refuelling aircraft and did so during the refuelling of C-FONF on March 10, 1989.

- Dryden airport management personnel did not ensure that the crash gate access roads at the airport were kept open and usable during the winter.

- Dryden CFR personnel reacted properly in hurrying to the crash area, setting up a command post, and assessing the crash.

- The Dryden airport manager did not cause to be issued, in a timely manner, a notice to airmen (NOTAM) regarding the lack of CFR services at the Dryden airport following the crash of C-FONF.

- Except for the initial radio contact between them, immediately after crew chief Kruger's arival at the crash site, Mr Kruger and Fire Chief Parry did not establish vital radio communications between the crash site and the command post, although they had radios capable of providing such communications.

- There was overlapping jurisdiction among the responding agencies, being the UT of O Fire Department, the Dryden CFR unit, and the OPP. This overlapping jurisdiction caused confusion and uncertainty as to the respective roles of those agencies involved.

- It cannot be shown that any activities by any person or organization in response to the crash altered, or could have altered, the fate of any of the persons who died as a result of the crash.

- By 12:45 p.m. there were several fire-fighters and at least three fire-fighting vehicles at the crash site capable of being used effectively to fight the aircraft fire, but there was no attempt to do so until after 1:30 p.m., when a UT of O pumper truck was driven to a position opposite the crash site.

- Handlines could have been in use at the aircraft fire by approximately 12:50 p.m. at the earliest. They could have been used to assist rescue personnel, preserve more of the evidence, and protect the flight recorders from the fire and heat.

- As the result of inadequate training, the CFR fire-fighters, including the CFR fire chief, did not carry out their duties and responsibilities at the crash site as professional fire-fighters but instead spent their time performing duties that others could have performed. This is not to suggest that the duties they did perform were not important; they became distracted by their concern for the survivors.

- The UT of O fire-fighters likewise did not initially perform duties as trained fire-fighters but became, as did the CFR personnel, distracted by the survivors.

- The CFR fire chief did not properly direct the fire-fighters on their arrival at the crash area.

- Although Transport Canada headquarters officials stated that there could be no compromise in safety standards caused by spending reductions, the fact that they did not specify whether CFR was a safety issue created problems for Transport Canada regional officers and for airport management.

- The recently instituted Transport Canada fire-fighter certification program provides a comprehensive means to ensure compliance with fire-fighter standards on a national basis in Canada.

RECOMMENDATIONS

It is recommended:

MCR 23 That Transport Canada ensure that airport authorities at all Canadian airports, in conjunction with crash, fire-fighting, and rescue (CFR) unit personnel, determine the best and most practical ways to deal with emergencies within each airport boundary and critical rescue and fire-fighting access area (CRFAA), having regard to available CFR personnel and equipment and to the surrounding terrain.

MCR 24 That Transport Canada ensure that all documents which describe or refer to the critical rescue and fire-fighting access area (CRFAA), be they Transport Canada documents or local airport authority documents, are informative, consistent, and unambiguous with regard to the CRFAA, and that such documents specifically define the responsibilities of a crash, fire-fighting, and rescue unit within the CRFAA both within the airport boundaries and/or beyond.

MCR 25 That Transport Canada ensure, through the fire-fighter certification program, and other programs and agreements as

necessary, that all crash, fire-fighting, and rescue fire-fighters, including the fire chiefs, are adequately trained.

MCR 26 That Transport Canada proffer for enactment legislation that empowers Transport Canada to ensure that all crash, fire-fighting, and rescue (CFR) personnel, including those at non-Transport Canada–owned and non-Transport Canada–operated airports, meet Transport Canada CFR training and operating standards.

MCR 27 That Transport Canada encourage all communities where there is an airport with fire-fighting services to include in their mutual aid/emergency response plans specific instructions regarding the duties, responsibilities, and area of authority of each organization that is expected to respond to an aircraft emergency on and/or off airport property.

MCR 28 That Transport Canada ensure that refuellers at Transport Canada–subsidized or operated airports are fully knowledgeable in and follow safe refuelling practices.

MCR 29 That Transport Canada implement a policy of having airport crash, fire-fighting, and rescue units, after appropriate training, responsible for monitoring aircraft fuelling procedures and ensuring compliance with fuelling standards and procedures.

MCR 30 That Transport Canada ensure that training programs for airport crash, fire-fighting, and rescue units include preparing fire-fighters for the realities of an air crash, so that they are not distracted from their primary responsibilities at a crash site.

MCR 31 That whenever a crash, fire-fighting, and rescue (CFR) unit responds to an aircraft crash, Transport Canada, as part of its post-crash response, objectively review and analyse the actions of the CFR unit forthwith, in order that deficiencies in the CFR response can be corrected and useful information, on both the positive and negative aspects of the response, may be passed on to other CFR units.

MCR 32 That Transport Canada ensure that local arrangements be made between airport managers and air carriers that will result in crash, fire-fighting, and rescue personnel being

informed of the number of persons on board, fuel on board, and any hazardous cargo on board an aircraft in the shortest possible time following an incident or accident. These procedures should accommodate the possibility that the aircraft flight crew will not be able to provide this information.

PART FOUR

AIRCRAFT INVESTIGATION PROCESS AND ANALYSIS

10 TECHNICAL INVESTIGATION

The Aircraft and Its Systems

Conduct of the Investigation

This chapter is based on reports prepared for the Commission by Canadian Aviation Safety Board (CASB) investigators, by interested-party participants, and, where indicated, by other investigators working independently. It also draws on the evidence given at the Commission hearings.

Upon receipt of notification of the Air Ontario F-28 crash at Dryden, the director of investigations of CASB, following the normal procedures for major aircraft accidents, mobilized the pre-designated investigation response team (Go-Team). The Go-Team comprised the following: the investigator in charge, a head office coordinator, a deputy investigator in charge, an administration officer, a regional coordinator, and 12 group chairpersons. The groups were: aircraft powerplants; aircraft structures; aircraft systems; flight data recorder and cockpit voice recorder; human factors and survivability; operations; photo and video; public affairs; records and documents; site security and survey; weather/air traffic control and airports; and witnesses. A special performance subgroup, formed shortly after the accident, worked with the operations group. Ten additional CASB investigators worked within the group system.

Arrangements for accommodation, expenses, and travel were completed by CASB administration staff while the investigators carried out preparatory duties for their areas of responsibility. A briefing held in the late afternoon and evening of March 10, 1989, brought everyone up to date on the known facts surrounding the accident and ensured that the investigators were prepared. Most of the team members departed Ottawa airport early the next morning on a de Havilland Dash-8 operated by Transport Canada, arriving at Dryden at approximately 11 a.m. local time. The balance of the team travelled in a Beech King Air, also operated by Transport Canada, and on commercial airlines. All investigators were in Dryden by the evening of March 11, 1989. The investigation headquarters were set up in a Ministry of Natural Resources building on Dryden Municipal Airport property.

The investigation was conducted in accordance with established procedures, applicable legislation, and regulations in effect at the time:

- *The Canadian Aviation Safety Board Act* and Regulations, R.S.C. 1985, c-12
- CASB's Manual of Investigation Operations
- The International Civil Aviation Organization (ICAO) Manual of Aircraft Accident Investigation
- Annex 13 to the Convention on International Civil Aviation (*International Standards and Recommended Practices, Air Accident Investigation*)

Observers representing parties with direct interest in the accident assisted the CASB investigators in appropriate areas of investigation and made their own observations in all phases of the field investigation. There were observers from Air Ontario, Transport Canada, the Canadian Air Line Pilots Association (CALPA), the Canadian Union of Public Employees (CUPE, representing flight attendants), Fokker Aircraft, Rolls-Royce (manufacturer of the aircraft's engines), and insurance companies. An aircraft-accident investigator from the Department of National Defence assisted in the investigation as part of his own training.

Pursuant to Order in Council P.C. 1989-532, passed on March 29, 1989, a public inquiry was ordered, and the investigation of this accident was turned over to this Commission of Inquiry. The responsibility of CASB in this investigation was terminated. At my request, the CASB team of investigators already involved in the investigation of the accident, including the investigator in charge, Mr Joseph Jackson, and three aviation technical experts, Messrs David Rohrer, David Adams, and Reginald Lanthier, were seconded to my Commission and thereafter reported directly to me. Representatives from interested parties having expertise in areas of interest to the CASB investigation team were assigned to work as full participants with particular CASB groups. As an example, CALPA provided the operations group with representatives offering expertise as pilots and performance engineers, and Air Ontario provided the aircraft structures group with those knowledgeable about the F-28 aircraft. In some instances, these individuals had initially served as observers on the CASB investigation teams. These participants were given access to all investigation information gathered prior to their having joined the investigation and had more investigative responsibility than that enjoyed by the observers. The participants were of great value to the investigation and were able to offer information of a highly specific nature in relation to their organizations.

At the end of the active investigation phase, the participants helped prepare their group's factual report. Each participant either signed his or her group's report as an indication of agreement with its contents or provided a written explanation of why he or she could not agree. The few differences of view that arose were resolved before the final

investigative group reports were submitted to this Commission. Various group chairpersons thereafter appeared on the witness stand at the Commission hearings and were questioned on the contents of their reports.

Initial Investigative Activity and Observations

Members of the CASB investigation team arrived at the accident site at approximately noon on March 11, 1989. At that time, members of the Ontario Provincial Police (OPP) were controlling access to the site, and fire-fighters had extinguished the fire. In order to ensure that evidence was not lost, none of the bodies and no part of the wreckage, other than as necessary during the rescue and fire-fighting operations, had been moved. CASB photographers photographed and videotaped the entire accident scene, and other CASB investigators made a cursory inspection of the area. Over the next days the OPP removed bodies and belongings.

An OPP district search and rescue team, together with CASB personnel, searched the area from the end of runway 29 to the crash site out to 100 m on either side of the wreckage trail. The locations of all the debris from the aircraft were subsequently plotted on a diagram, with information obtained from surveying results, ground plots, and photographs taken from the air. The accuracy of the survey is estimated to be within 10 cm in horizontal and vertical positioning with reference to the elevation of the Dryden airport. Before being removed, each piece of wreckage was photographed with a 35 mm camera.

The site security and survey group determined that the aircraft first contacted a single tree 127 m off the end of runway 29, 3° to the left of the runway centre line. The treetop was broken off at an elevation of 413.1 m above sea level (asl); the west end of the runway is 413 m asl. The aircraft struck 18 more trees in the next 600 m, all at an elevation of 413 m asl, plus or minus 1.5 m. The aircraft then contacted a more heavily wooded area at the top of a knoll and started to descend. It struck the ground and slid about 80 m before coming to rest. The knoll elevation was 404 m asl and sloped downwards to 390 m asl, where the aircraft came to rest.

Vertical colour and infrared photography and subsequent evaluation using photogrammetric techniques established the exact position and height of the cut-off trees. It is estimated that this technique registered the tree heights within a standard deviation of 10 cm.

The first piece of wreckage located on the wreckage trail was the broken red lens cap from the rotating beacon on the lower fuselage of the aircraft. Lens pieces were found in the vicinity of the first tree strike. The left wing tip, the main landing-gear doors, and pieces of the radome were found in the heavily wooded area on the knoll where the aircraft

started to break up from striking the trees. As the aircraft entered the heavily wooded area, the wings were relatively level; however, as it travelled through the trees, it rolled some 10 to 20° to the left. Most of the left wing broke away in pieces before the fuselage struck the ground. The wreckage along the trail consisted primarily of parts of the left wing, the main landing-gear doors, and the underside of the fuselage.

The main wreckage came to rest upright and consisted of three relatively intact major pieces, joined on the left side and in the form of a U, with the tail and nose sections pointing backwards, towards the airport. There were two large breaks in the fuselage, one just aft of the main passenger door and one through the fuselage at approximately seat row 12. The centre fuselage section came to rest approximately perpendicular to the flight path, the tail section was oriented about 50° off the centre line of the fuselage, and the cockpit was about 90° to the fuselage.

Fire broke out coincident with the rupturing of the left-wing fuel tank, approximately 50 m beyond where the aircraft entered the heavily wooded area. The fire along the wreckage trail superficially burned the trees but was not sustained after the sprayed fuel had burned. After the aircraft came to rest, the fire continued to burn until it was extinguished by fire-fighters, about two hours after the crash. The cockpit and fuselage aft to the rear pressure bulkhead were almost totally destroyed by fire. The empennage (tail section) and engines were lightly sooted and relatively unburned. There was no evidence that the aircraft was on fire prior to the main tree strikes.

Following documentation of the wreckage *in situ* and subsequent on-scene examination, all wreckage that could be found was either locked in trunks/crates or guarded by security personnel, before being moved by air, truck, and rail to the CASB engineering laboratory in Ottawa. Detailed examination of all pieces of the wreckage was then carried out by CASB investigators as well as by others under their supervision. After the snow had melted at the accident site, another search was conducted. Further pieces of wreckage were found; these too were documented, sent to the laboratory in Ottawa, and examined.

Reconstruction and examination of the wreckage and of the breakup patterns showed that all aircraft damage was consistent with collision with trees or the ground.

The aircraft flight path and wreckage location were pictorially reconstructed, and the results are reproduced in the report of the aircraft structures and the site security and survey groups. (This detailed report, which graphically describes the actual flight path and resulting crash, is included in its entirety as technical appendix 1 to my Report.)

Engines

Aircraft C-FONF was equipped with two Rolls-Royce Spey RB 183-2 Mk555-15 jet engines, one attached to each side of the rear fuselage. When viewed from the rear, the engine on the left side is designated number 1 and that on the right side is designated number 2. The engines provide thrust; power to drive accessories connected to the engines; and hot air from the engine compressor for, among other things, air-conditioning, pressurization, and airframe anti-icing.

On-site examination of the wreckage revealed that the engines were still securely mounted to the aircraft and had suffered minimal damage. The left engine was damaged as follows: the engine was still cowled, but the bottom of the cowling was impact damaged; the hinged portion of the cowling was severely damaged; the gearbox was fractured; the engine nose cowl and tailpipe were dented upwards and the cowl was forced against the compressor; and all components from the left engine appeared to be contained within the engine cowlings. The right engine was found completely cowled and had been subjected to only minor impact damage. The low pressure (LP) compressor was free to rotate and was still coupled to the LP turbine, and the LP compressor blades showed damage from foreign objects.

To detach the engines from the aircraft, the engine pylons (stubwings) were cut from the aircraft structure with the engines still attached. The units were then shipped in a sealed trailer to the engineering laboratory of the Canadian Aviation Safety Board in Ottawa. The engines were subsequently shipped to the Rolls-Royce (Canada) facility in Montreal for disassembly and examination under the supervision of CASB investigator William Taylor. Following the examinations at the Rolls-Royce (Canada) facility, all components from the stubwings and engines were shipped back to the CASB engineering laboratory for further study and analysis both by CASB investigators and by an independent engine-management consultant retained by this Commission, Mr Peter Clay.

Number 1 (Left) Engine

The number 1 (left) engine (serial number 9130) was generally intact, although the lower and aft cowling panels were torn and partially burned. The lower portion of the compressor's intermediate case was split adjacent to the rear flange, and the gearbox case was broken. The accessory units were externally damaged, with most of them separated at their mounting flanges. The engine power controls were broken and twisted. The emergency fuel shutoff mechanism had been shifted to the off position by the breakup, and the low-pressure shaft failure system had not been actuated. This was demonstrated by an intact shear pin in

the cable quadrant on the side of the engine. If the low-pressure shaft disconnects from the turbine while the engine is running, the failure system causes a cable to actuate the emergency fuel shutoff, thus shutting down the engine to prevent further damage.

The engine anti-ice valves were found in the closed position. When selected ON (open), and there is both electrical power and air pressure available, these valves open – and they are held open – by the electrical power and the air pressure. With failure of either electrical power or air pressure, the valves move to the closed position. The internal area of the engine anti-ice ducting was examined for ingested vegetation. Small amounts of vegetation were found, but it could not be established if the vegetation entered via the engine compressor, which would indicate that the anti-ice was on, through breaks in the structure, or through normal air exit points. An examination and a basic electrical test of the anti-ice shutoff valves showed that the valves were serviceable. Equipment for a full functional check was not readily available; however, there was no reason to suspect that the valves would not operate as required. The anti-ice gauge-pressure transmitter was serviceable.

The fuel spray nozzles were heavily sooted but were not damaged. Testing of the nozzles showed some streakiness during low-pressure flow, but, except for a marginally low flow rate on several nozzles, the nozzle set was serviceable under combined flow conditions, as is the case at high engine-power settings. There was much discussion about the serviceability of the fuel nozzles because the Rolls-Royce test data showed that most or all of the nozzles tested out of limits. In the opinion of the powerplants group's chairman, Mr Joseph Bajada, there was nothing in the reports regarding the nozzles or other fuel control components to alarm him or indicate any inability of the fuel delivery systems.

In an attempt to establish the relative position of the torque shaft of the compressor bleed valve at the time vegetation and other foreign material was passing through the engine, investigators examined the debris pattern on the torque shaft. No identifiable pattern was found. The position of the torque shaft would indicate the position of the bleed valve, which in turn would give an indication of engine power. The valve is closed when the engine operates at high power.

The LP compressor was damaged by debris: five first-stage blades (one near the root) and one second-stage blade were broken. Other blades in the compressor were gouged and bent. All the breaks were the result of overload at impact. Some blades in the high pressure (HP) compressor showed minor damage in the form of nicks, rubs, and minor bends. The turbine sections were in generally good condition, but there were extensive metal deposits throughout the entire HP and LP turbines and, especially, on the HP nozzle guide vanes.

All bearings were in good condition, with no evidence of a distress or other lubrication problem. The oil tank was ruptured; no oil sample was available, but the filters appeared clean on visual inspection. The magnetic plugs were clean.

Number 2 (Right) Engine

There was little external damage to the number 2 right engine (serial number 9187). There was some post-crash fire damage to the pylon, but the engine was not affected.

The fuel HP shutoff valve arm was at mid-travel, and the LP shaft failure system had not been actuated. The power lever linkage to the fuel regulator unit was found at the MAX position. Normally, this would indicate that the engine had been selected to full power; however, the linkage could have been moved to MAX as a result of the breaking up of the linkage during the crash.

The observation and conclusions about the engine anti-ice valves for the left engine apply to the right-engine valves, except that the gauge-pressure transmitter, although functioning acceptably, leaked a small amount.

Functional tests of all fuel system components were performed, with the results much the same as for the left engine. A fuel sample was obtained from the engine fuel lines. The fuel sample was straw coloured and contained no visible free water or suspended matter. The sample did contain traces of fine black particles and several other small pieces of particulate matter; National Research Council Canada (NRC) concluded that the amount was not excessive. The simulated distillation characteristics of the sample indicated a mixture of fuel types.

Examination of the bleed-valve torque shaft for fan duct debris showed that, when ingested vegetation collected on the shaft, the valve was in the bleed-valve–closed position. The bleed valve is closed when the engine is operating at high power.

The T6 thermocouples, which measure turbine gas temperature, were checked for continuity. One was internally shorted, but it was not determined whether the short was in the controlling or the indicating section; either system will continue to function acceptably with one probe unserviceable.

The adjustment of the rod that actuates the switch to control the selection of seventh- or twelfth-stage air was found to be incorrect, with the clearance being less than specified. The function of this switch is to match bleed-air output to the airframe pneumatic system requirements. Incorrect adjustment would have had no effect on engine operation.

The interior of the right engine showed a greater accumulation of tree debris, in finely chopped form, than was found in the left engine. In the fan duct there was vegetation packed in the exhaust collector's support

struts and at flanges, and there was a collection of charred vegetation around the inlet areas of the burner cans.

The LP compressor had one broken blade, broken in overload, with others moderately gouged and bent. The overall condition was good relative to the amount of debris ingested. The HP compressor suffered light damage. A heavy coating of soot appeared throughout much of the engine, especially in the HP compressor area. A sample of the soot was analysed by NRC's chemistry division, and the soot was found to be organic material related to tree fragments and other objects ingested during the crash. The turbines were also sooted, and there was metal spatter throughout the engine to the number 2 LP turbine. The metal deposits were not as heavy as in the left engine.

The oil tank had ruptured, and only a small oil sample was recovered for analysis. From visual inspection, all bearings and filters were in good condition and there was no indication of a lubrication problem. The magnetic plugs were clean.

Engine Accessories

The engine accessories from both engines, including the constant speed drives, were delivered to the appropriate manufacturer's facilities and were functionally tested under the supervision of CASB investigators. Accessories that were damaged and could not be tested were disassembled and examined. No discrepancies that could adversely affect engine operation were found in the components tested and examined.

The airflow control unit and the fuel flow regulator of the right engine were bench tested and found to be slightly out of specified limits on some points. The airflow control unit controls the position of the compressor inlet guide vanes, and at takeoff power the guide vanes are in the full open position. Both the engine and the aircraft manufacturers commented that the out-of-limits condition existed at a point where the inlet guide vanes would already be fully open and, therefore, would have no effect on engine power at takeoff. At takeoff power, the fuel flow regulator condition would result in a slight thrust increase above normal.

Oil Analysis

The oil sample recovered from the oil filter housing of the right engine was analysed by National Research Council Canada (NRC). The analysis showed the oil to be typical of synthetic ester-type aviation turbine oil. Approximately 75 mg of particulate material was filtered from the 75 mL sample. The material was identified as mostly silicious matter plus a few fibres and bits of vegetation. The sample did not include any other type of contamination, and there was no indication that the oil had been subjected to undue oxidation.

Fuel Analysis

Fuel samples were collected from the fuel delivery vehicles in Dryden (Jet B) and Thunder Bay (Jet A), and a small sample was recovered from a fuel line on the right engine. The samples were analysed at the NRC.

The Jet B and Jet A samples were clear, water white, and contained no visible free water, suspended matter, or sediment. The Jet B sample contained 0.13 and the Jet A sample 0.31 mg/L of particulate matter; the maximum allowable particulate matter at time of delivery to an aircraft is 0.44 mg/L. Both samples met all the specification requirements for which they were analysed, including the distillation characteristics.

Metal Spatter Analysis and Engine Power

Samples of the metal spatter deposited on the turbine blades of each engine were collected. Dr Kenneth Pickwick, CASB's chief of physical analysis, examined the samples at the CASB laboratory in Ottawa, using a scanning electron microscope and subjecting the samples to energy-dispersive X-ray analysis. Dr Pickwick has a doctorate in metallurgy from the University of Manchester. He served two years as a postdoctoral fellow in the NRC's applied chemistry division before joining CASB.

CASB's physical analysis section is charged with two general areas of concern: fractographic analysis, the examination of fracture surfaces with a view to determining modes of failure and causes of failure, for which electron optic machines are used; and the determination of the chemical compositions of materials, for which a full range of X-ray spectrometric equipment is used. The spatter material from the blades was found to be the same aluminum alloy used in the LP compressor blades.

It has been the experience of the manufacturer, Rolls-Royce, that extensive diffusion within the limited time available during engine failure from ground contact can occur only if the turbine's operating temperatures are sufficient to sustain the aluminum-based component of the spatter in the molten state. The blade material has solidus and liquidus temperatures of 549 and 638°C, respectively. Thus, over an operating range of 550 to 640°C, some proportion of liquid aluminum would be present in the spattered deposits.

During the developmental stage of this engine type, the manufacturer conducted thermal-indicator paint studies of the temperature distribution in various locations of the turbine assembly of the engine. The paint used is colour sensitive to temperature and duration at temperature. These studies indicated that the temperature of the LP2 turbine, especially on the midspan range of the turbine blades, approached and exceeded the range of 550 to 640°C for all engine operating levels above cruise power. The temperatures existing in the LP turbine areas of both engines during the failure sequence were sufficient to allow aluminum

diffusion into the blade surfaces (that is, they were in the 550–640 C range). Accordingly, it can be concluded that both engines were operating at or above the cruise power range at the time of failure of the LP compressor blades.

During Dr Pickwick's testimony it was pointed out that there were some variables which the investigators did not take into account in their temperature and power determinations:

1 All 20 burners on these engines were out of specification.
2 The combined flow rates from 16 of the 20 engine fuel nozzles were out of specification.
3 Two of the engine burners were leaking at 1500 pounds per square inch (psi).
4 Some of the fuel nozzles exhibited very streaky spray patterns.
5 The fuel nozzles from the burners were very heavily sooted.
6 Jet B fuel may burn at a different temperature from Jet A fuel. (The fuel in C-FONF was a mixture of Jet A and Jet B, and the manufacturer used Jet A during the temperature tests.)
7 The fuel/air mixture of the engines is affected by the sooted fuel nozzles.
8 An engine malfunction such as a compressor stall may have affected engine power.

Dr Pickwick agreed in testimony that, in determining the power level of the engines, he had assumed the engines were functioning properly just prior to the time that the metal diffusion occurred. His conclusions were based on the premise that none of the variables mentioned above would affect the evaluation of the engines. At the end of his testimony, Dr Pickwick agreed that, to the best of his knowledge, the temperatures were consistent with cruise power or better at the time of the incident.

Mr Clay commented in his testimony on the variables mentioned above. He was contracted by the Commission to participate in this investigation as an independent engine analyst who would provide another opinion about the engines of C-FONF. He is a fellow of the Institution of Mechanical Engineers, a fellow of the Institution of Production Engineers, and a member of the Royal Aeronautical Society; while he resided in Quebec, he was a member of the Corporation of Professional Engineers of that province. Mr Clay started working at Rolls-Royce, United Kingdom, in 1943, at the same time studying at the College of Technology in Darby. Graduating in 1949, he continued his postgraduate studies for about another 10 years while working with Rolls-Royce, where he trained in all aspects of engine repair and overhaul. Throughout his career with Rolls-Royce, Mr Clay specialized in engine design, development, manufacturing, and product support. At

the time of his retirement from Rolls-Royce in 1982, Mr Clay was working in Montreal as the director of product support responsible for Rolls-Royce products in service in Canada, the United States, Central America, and Venezuela. He has been involved as an investigator in other aircraft accidents where Rolls-Royce engines powered the aircraft and where engine teardowns were required.

Mr Clay provided insight into the variables mentioned above. Variables 1, 2, 5, and 7 pertain to the nozzles. Mr Clay's evidence was that the noted variations in the nozzles would have no effect on engine operation. The fuel control system is flow sensitive, and the fuel flow regulator ensures that the proper flow is achieved for a set (requested) engine condition by varying the fuel pressure to the nozzles. Mr Clay also stated that he "wouldn't expect, on flows and angles, any burners [nozzles] taken from service to differ to these" (Transcript, vol. 62, p. 15). In response to a question regarding the nozzles, Mr Clay stated:

> A. ...The condition of these fuel nozzles was such that it would not have had any effect on combustion. The fact that they are outside the new or fully overhauled limits, those limits are established to ensure that, with the normal deterioration and sooting which occurs throughout the life of the engine, they will still be serviceable, not new, but they will still be serviceable at the end of that life.
>
> (Transcript, vol. 62, p. 63)

Regarding variable 3, the normal combined flow-nozzle operating pressure is 500 psi. Mr Clay placed no significance on the fact that two of the nozzles leaked slightly, at 1500 psi.

Variable 4 pertains to the nozzles and the primary fuel flow. The primary flow is active alone (that is, not in conjunction with secondary flow) only during engine startup to approximately 20 per cent N_2. Above 20 per cent N_2, there is both primary and secondary fuel flow. In Mr Clay's view, there was no significance in the fact that the flow was streaky.

Regarding variable 6, Mr Clay could not even conceive that the type of fuel being burned in the engine would make any difference, even going outside the range of normal fuels. There is virtually no difference in calorific value among fuels variously called Jet A, Jet B, JP1, JP4, Avtur, or Avtag.

In a letter dated December 1989, the powerplants chairman, Mr Bajada, requested information from Rolls-Royce regarding compressor stalls. Among several questions, he asked whether, during compressor stall or air disruption as may have been encountered while the aircraft was going through the trees, the LP2 blade temperature rises. Rolls-Royce replied:

> During compressor stall or air disruption a rise in turbine gas temperature can occur. The effect of this on the L.P.2 turbine blades, however, is not immediate and depends on the duration of the temperature increase. Small increases in gas temperature over a few seconds do not necessarily result in an increase in L.P.2 blade temperature. If the increase in gas temperature is maintained, this will, of course, produce an increase in the temperature of the L.P.2 blades.
>
> (Exhibit 452, appendix Q)

Mr Bajada also asked Rolls-Royce whether, in the event of compressor stall or air disruption, the airflow within the engine is sufficient to carry the aluminum material to diffusion on the LP2 blades. Rolls-Royce responded:

> During a compressor stall condition air continues to flow through the engine and would therefore be capable of carrying pieces of aluminium debris to the L.P.2 blades.
>
> A compressor stall we define as an unstable airflow in some of the stages.
>
> (Ibid.)

Engine Assessment by Rolls-Royce

The engines were disassembled and examined, under the control of CASB, at the Rolls-Royce (Canada) facility during the period April 24–28, 1989. Rolls-Royce engine experts personally provided technical assistance as required. A report was compiled by Rolls-Royce to record the condition of both engines at disassembly. The conclusions drawn in the report are as follows:

> 2.0 CONCLUSIONS
>
> 2.1 Examination of Spey Mark 555-15 Engine Numbers 9130 and 9187 at Rolls-Royce (Canada) Ltd, revealed no evidence of a pre-impact mechanical failure or malfunction.
>
> 2.2 Examination and testing of accessory units from both engines revealed no evidence of any malfunction or mechanical failure which could have affected engine operation.
>
> (Exhibit 504, p. 2)

Engine Assessment by Mr Peter Clay

Mr Peter Clay, the independent engine consultant, visited the CASB engineering laboratory, where he viewed the disassembled engines and related data and talked to CASB staff. Drawing on his observations and knowledge, he came to the following conclusions, which are taken from both his testimony and his report for the Commission (Exhibit 466).

1. There was no evidence of any failure or unserviceability being present prior to initial ingestion/impact.
2. All damage observed was consequent upon foreign-object ingestion and tree and ground impact.
3. The low-pressure compressor damage resulted from ingestion and impact of and with trees, aircraft material, and the ground.
4. There was no evidence to suggest any impediment to achievement of the full power range of the engines. In fact, the evidence supports the fact that the engines were at high power beyond the points of debris ingestion and through to major external impact.
5. The anti-icing systems on both engines were operating beyond the point of initial foliage ingestion. Since the valving was fully operational on post-accident bench test, it is correct to conclude the system was operating throughout.
6. The material temperatures in the later stages of the high-pressure compressor of the right engine were of the order of 400°C at the time of final impact and cessation of engine rotation. These HP compressor components would be in the 400°C temperature range with the engine at takeoff power at the ambients present at the time of the accident. This conclusion is evidenced by sooting, and by the form and texture of the sooting, found on these components.
7. All oil and fuel filters and oil scavenge strainers were clean. The magnetic plugs sampling the total oil system had the usual minor amounts of sludge around their periphery, with no trace of metal particles. All bearings, air and oil seals, and oil passages were in good condition.

Mr Clay in his report also commented on the diffusion of aluminum throughout the turbines of both engines, the position of the bleed valves, and the anti-ice selection. His conclusions are summarized below:

1. Examination of sections taken from the LP2 turbine blades from both engines reveals the initiation of grain-boundary penetration of molten aluminum into the Nimonic of the blade, in the active area with the aluminum coating. This evidence confirms that the aluminum remained molten and that the host blade remained at a suitable temperature to promote the conditions found. For the turbine to be at this temperature requires a high engine-power setting. It is clear from this evidence that both engines were operating at high power when material from the LP compressors was in the system (following the initial impact and ingestion, which caused the release of such material). Penetration and diffusion were more advanced on the right engine because, although the blade temperatures at onset were comparable, the operating time was less on the left engine.

2 Debris deposited on the bleed-valve quill shafts established that the bleed valves were closed, as they ought to be at the higher operating condition (high power).
3 The engine anti-icing system was free and clear and capable of operation, and the valves were operative on bench check. That the system was operating at the time of ingestion/impact is evidenced by the presence of pine needles and other foliage debris in the piping, in the nose fairing (the bullet), and in the nose cowl. The nose fairing on either engine had not been penetrated by external impact; therefore, since the nose-cowl flow is downstream of the fairing, the debris had to come through the system.

Engine Sounds at Takeoff from Dryden

Witness Description Witnesses who were in the aircraft or on the ground described their recollections of the sounds of the engines during the takeoff roll at Dryden and while the aircraft was airborne.

Mr Norbert Altmann, a commercial pilot, was in the terminal building and saw the aircraft near the departure end of runway 29. He was walking through the terminal building and heard a "muffled roar" of the engines of the F-28 on the takeoff roll (Transcript, vol. 22, p. 189).

Mr David Berezuk, a Dash-8 captain with Air Ontario, was seated in 12A. He described the power application as "smooth," without any "unusual engine noises," as the aircraft accelerated down the runway (Transcript, vol. 14, pp. 82, 86).

Mr John Biro is a retired RCAF technician and was seated in 11E. He did not recall anything unusual about the sound of the engines at any time or any sense of power-on or power-off during rotation. He did remember "quite clearly that the right engine ... was just above and behind" where he was sitting, and "the sound from it didn't change at all" until the aircraft "started hitting the trees" (Transcript, vol. 21, p. 54).

Mr Craig Brown is a commercial pilot and was on the east side of the terminal ramp. To him, the engines "sounded normal. The engines powered up, and there was nothing that I noticed or took note of" (Transcript, vol. 5, p. 245).

Mr Ricardo Campbell was seated in 7D. He heard no change in engine noise, "just loud jets, full force of a jet, now loud and fast ... I heard it." He did not hear "anything unusual" about the engine sound coming out of Dryden (Transcript, vol. 17, pp. 52, 94).

Mr Vaughan Cochrane was the general manager of the Dryden Flight Centre and is a pilot. He was on the tarmac by the fuel cabinets. During the takeoff, he was looking directly at the aircraft. He did not hear

"anything at all unusual about the engine noise" (Transcript, vol. 53, p. 237).

Mr Donald Crawshaw was seated in 13B. During the initial part of the takeoff roll there was nothing unusual that caught his attention. However, on rotation the aircraft "just seemed to lose a little bit of power – or a lot of power, actually, and it came back down, and power was again put to the engines, it went back up a little bit, then came back down again" (Transcript, vol. 17, p. 308). He noted that "where we were sitting was right by the left engine, and, on our – on the initial takeoff, it was whining pretty good like one of those engines do, and then there was nothing and the plane flattened out. And then there was a lot of power put back to it again" (ibid.). Mr Crawshaw equated the sound as the aircraft was rolling down the runway to that of "a DC-9" (Transcript, vol. 17, p. 319). The aircraft was in the air when the decrease and increase in sound occurred.

Mr James Esh worked for Dryden Air Services as a baggage handler and is also a private pilot. At the time of the accident he was near the fuel cabinets. He did not describe the engine sounds he may have heard as the aircraft was taking off, but he stated that, as the aircraft disappeared behind the trees, he heard the engines "still screaming away" with no unusual noises (Transcript, vol. 24, p. 204).

Mr Jerry Fillier worked for Dryden Flight Centre and was by the fuel cabinets. He observed the takeoff run but did not hear "any unusual sounds coming from the engines" (Transcript, vol. 25, p. 46).

Mr Michael Gatto was seated in 11A. To Mr Gatto, the engines sounded sluggish as the aircraft proceeded down the runway. They did not have that high-pitched sound. He recalled the high-pitched sound as the aircraft took off at Thunder Bay, but in Dryden that sound was not there. "It just didn't feel that they had full steam. It didn't feel like it was going to its full max" (Transcript, vol. 13, p. 128).

Mr Raymond Gibbs is a commercial pilot and was in the airport manager's office. He neither saw nor heard anything unusual as the aircraft took off. He heard the engine noise, and it "sounded like a typical jet engine" (Transcript, vol. 23, p. 39).

Mr Daniel Godin was seated in 9B. He heard nothing abnormal and remembered hearing "the engines seemingly at full power with no noises" that would have been alarming to him. He also "distinctly remember[ed]" the engines running while the aircraft was in the crash sequence (Transcript, vol. 17, pp. 189, 193).

Mr Murray Haines, a DC-9 captain with Air Canada, was seated in 13D, between the engines. To him, the engines were "running perfectly," and they "both made a lot of noise." Based on his experience flying jets, "those engines sounded good" (Transcript, vol. 19, p. 39).

Mr Thomas Harris was seated in 8A. To Mr Harris, everything appeared to be normal until about half to three-quarters of the way down the runway, when he heard what appeared to be "a momentary change in pitch of the engines," which he likened to "a throttle-off, throttle-on instantaneous type engine noise" (Transcript, vol. 12, p. 173).

Mrs Sonia Hartwick, a flight attendant on the flight, was seated in 8D. She heard "nothing" that she "noticed that was unusual" during the takeoff (Transcript, vol. 10, p. 238).

Mr Roscoe Hodgins is a commercial pilot who observed the F-28 take off while he was standing near the Ministry of Natural Resources building. He described the acceleration of the aircraft as slow, and

> A. ...as the engines spooled up and came up to full throttle, there wasn't a steady whine or crackling noise of a jet engine.
>
> Normally on jet engines, any that I have heard, have a steady whine or swish to them, a high-pitched, ear-piercing noise. This had an intermittent burping noise to it which was happening maybe every three to four seconds.
>
> (Transcript, vol. 22, p. 144)

According to Mr Hodgins, the intermittent burping noise came at regular intervals and continued throughout the takeoff sequence. At rotation, the engine noise seemed to die off, which Mr Hodgins attributed to the fact that the jet blast was pointed down at the runway; however, as the aircraft started to fly, he could again hear the intermittent burping noise. Mr Hodgins had observed the F-28 take off from Dryden approximately 12 to 15 times in the two-and-one-half weeks prior to the crash. At those times he heard only "the normal high-pitch scream of a jet engine" (Transcript, vol. 22, p. 146).

Mr Gary Jackson was seated in 13A. He recalled the engines being powered up, and they sounded normal. He stated that there was "a slight wavering to the pitch, but that's all" (Transcript, vol. 16, p. 144). When the aircraft was at about 15 or 20 feet, he then heard what he thought was "extra power going to the engines. They increased in intensity, and we got a little bit more altitude" (Transcript, vol. 16, p. 132).

Mr Stanley Kruger, the crew chief of the Dryden crash fire rescue unit, was in a fire truck near the fire hall. He did not hear "anything unusual about the sounds of the engines" during the takeoff of the aircraft (Transcript, vol. 27, p. 67).

Mr Peter Louttit, the Dryden Municipal Airport manager, was in his office in the terminal; he is a former military pilot with about one thousand hours' experience flying the CF-100 jet aircraft. He saw the aircraft for a very short time during its takeoff, his impressions gained as it went by the intersection of taxiway Alpha and the runway. When

he observed the aircraft, it was at a point on the runway where, in Mr Louttit's opinion, the aircraft would normally already have been airborne. The aircraft was in a rotated attitude, with the main wheels still on the runway. When Mr Louttit saw the aircraft, its sound caught his attention. He described the sound as

> A. ... an intake noise. It was not the exhaust noise. The jet engine has an intake noise when it is approaching. It has an exhaust noise when it is going away. And it was an intake noise that I heard and it was a descending noise.
> ... It was quite – quite a sharp noise, explosive I guess would be a good word for the description of it.
> (Transcript, vol. 5, p. 23)

To Mr Louttit, the noise meant a malfunction in the engine, probably a flame-out, which is an engine failure. (He has experienced a flame-out while flying the CF-100 aircraft.) Mr Louttit stated that the noise was "very quick. It came, it went to high pitch, and was gone" (Transcript, vol. 5, p. 44).

Mr Ronald Mandich, of Green Bay, Wisconsin, who holds a master's degree in mechanical engineering from the Massachusetts Institute of Technology, was seated in 8C. He has a work history with Hughes Aircraft, involving the management of flight test programs and vibration testing. He testified that he has done extensive work in vibration analysis and testing. His evidence was that the aircraft left the runway and came back down. When the wheels hit the runway he noticed that, assuming both engines were going the same speed initially, the sound of one of the engines "decreased in pitch ... about a half an octave ... about four, five, six times." Just before the aircraft left the runway the second time, he heard the pitch of both engines "increase somewhere between 3 to 5 per cent, as if someone in the cockpit had advanced the thrust levers" (Transcript, vol. 17, p. 358). The engine noise that he heard was definitely not a "synchronization" noise; it was a "step function ... not a beat frequency phenomenon" (Transcript, vol. 17, pp. 375–76).

Mr Richard Waller was seated in 3D. Compared with the sound of the engines during takeoff from Thunder Bay, at Dryden the engines had a higher-pitched sound, "as if he had more throttle to the engines ... the engines were very, very loud, as if they were at full throttle" (Transcript, vol. 18, p. 149).

The following is a summary of the witness testimony regarding engine sounds. Of the 21 people who discussed engine sounds during testimony, 14 said that the engines sounded normal, were screaming away, were running perfectly, or that there was nothing unusual in the sound. The 7 other witnesses gave inconsistent testimony regarding the sounds of the engines. Two of these thought the engines were operating

normally, and one described a musical step-function sound; these three witnesses then heard power being added as or after the aircraft became airborne. Another thought the engines sounded sluggish and did not have full power; another described the sound as if the throttles had been moved instantaneously off then on, three-quarters of the way down the runway; another thought the engines were not making the normal steady whine or crackling noise of a jet and made burping sounds from the start of the takeoff until becoming airborne; and another heard a sharp, explosive noise like the sound of an engine flame-out as the aircraft passed taxiway Alpha: the noise came, went to a high pitch, then was gone.

Analysis of Engine Sounds Investigators who had examined the engines after the crash testified with respect to the question of whether the engine sounds described by the witnesses indicated possible engine malfunctions, specifically, engine compressor stall or engine flame-out.

Mr Joseph Bajada, the CASB powerplants group chairman, stated that there was no evidence of damage in the high-pressure compressor that would indicate there had been a severe compressor stall. Such evidence would include, for example, bent compressor blades, and none were found. (Compressor stalls create back pressure in the compressor area, which causes the blades to bend.) As well, Mr Bajada found no evidence from his examination of the engines of a flame-out having occurred on the takeoff roll.

Mr Bajada agreed that there can be "less severe" compressor stalls that do not damage the engines, but said these will result in bangs, or "a series of bangs," as the compressor stall goes through the engine (Transcript, vol. 60, pp. 143, 144).

Mr Bajada stated that he had reviewed testimony of a few witnesses with regard to the abnormal engine sounds they heard and discussed with Rolls-Royce personnel these sounds and their possible origins. Neither Mr Bajada nor Rolls-Royce could come to any conclusions over the source or cause of the abnormal sounds.

Mr Clay, the independent engine consultant, discussed the evidence that would have indicated a compressor stall had occurred. He stated that if there had been a very severe compressor stall, then, as the offloading and onloading of the HP compressor blades occurred, there would likely have been a "woof" sound. A severe compressor stall would also result in physical evidence, namely contact between the rotating blades and the static blades, since the blades, during onloading and offloading pressures, moved forward and rearward as they rotated. During his examination of both engines, Mr Clay did not find any such physical evidence in the HP compressor section.

Mr Clay commented on the engine sounds described by Mr Mandich. Mr Clay's theory was that when the pilot tried to rotate the aircraft, he found he was unable to do so, and the "first normal self-preservation reaction was to firewall the engine or engines" (Transcript, vol. 62, p. 27). To Mr Clay, this meant pushing the throttles forward just as fast as the pilot possibly could.

During cross-examination, Mr Clay stated that it is possible to have a compressor stall occur without any evidence being left within the engine. He also stated that if the stall is so minor as to leave no physical evidence, it is doubtful there would be any loss of power.

When questioned about whether the ingestion of ice, slush, or water into an engine could possibly cause a compressor stall, Mr Clay replied: "In sufficient quantity." He further described "sufficient quantity" as an "alarming amount." He explained that Rolls-Royce does tests where fire hoses are directed full bore into intakes of engines, and "all kinds of things" are shovelled into the engines. He was quite proud to say that "Rolls-Royce probably has the best record on their engines of exceeding all regulations in that regard" (Transcript, vol. 62, p. 55). In summary, the engine experts could give no explanation for the engine sounds heard by the witnesses, except for the sound of an increase in power at or after liftoff. It would be a natural reaction for the pilots to advance the throttles to maximum when it became apparent the aircraft was not flying properly.

Apart from the abnormal sounds described by some witnesses, there is no evidence that the engines were not operating normally throughout the takeoff and flight. Indications that the engines were operating normally are as follows: the flight crew did not reject the takeoff, so it can be assumed that the engine indications as seen and heard in the cockpit were normal up to the time the aircraft reached V_1 (the takeoff-decision speed); as demonstrated in the performance analysis, both engines had to have been operating to achieve the flight profile flown; and the physical examination and tests conducted on the engines and accessories did not reveal any reason why the engines could not have produced full power up to the time they started ingesting tree material. Although some witnesses heard abnormal engine sounds, it is considered that the conditions which produced those sounds were transient and did not affect the performance of the engines.

Engine Smoke on Startup at Winnipeg

Description of Occurrence On March 8, 1989, an Air Canada ground handler, Mr William O'Connell, worked on the turnaround of an Air Ontario F-28 aircraft in Winnipeg and observed the startup of the engines when the aircraft was ready to depart. According to his testimony, the engines were started using the aircraft's auxiliary power

unit. The number 2 (right) engine was started first, and it was a normal start. When the number 1 (left) engine was started, "excessive black smoke" came from the rear of that engine for a "good five minutes" before the engine stabilized (the smoke stopped) (Transcript, vol. 58, p. 55). The captain "opened the cockpit window and looked back at that number 1 engine at least three times" (ibid.). The wind was from the left, perpendicular to the aircraft fuselage. After the left engine stopped smoking, the aircraft taxied out for takeoff.

During the start, Mr O'Connell gave no signs to the crew to indicate that the engine was smoking; he was certain they were aware of the problem. Mr O'Connell described a "wet start" as a blast of flames out of the engine tailpipe that lasts only a few seconds, and he stated that what he saw was not a wet start. He described the smoke as being four or five times the normal volume one would get from an F-28 engine, and, although he had been working around jet aircraft for 21 years and had seen thousands of engine starts, he had never seen anything like this from a jet engine. Mr O'Connell did not know the registration of the aircraft, but it was later shown to have been C-FONF.

Analysis of the Engine Smoke The engine experts were asked to comment about why the engine smoked during startup.

Mr Bajada, the CASB powerplants group chairman, stated that, based on his experience with jet engines, he could not come to any conclusion as to why the smoke to which Mr O'Connell attested would have appeared. Mr Bajada talked to Rolls-Royce many times about the smoke, and the company could not provide an answer either. Mr Bajada did say that fuel pooling could cause "a little bit of black smoke on startup" (Transcript, vol. 60, p. 139), but he knew of no other reason for a jet to produce black smoke. Mr Clay, the independent engine consultant, stated:

> A. With no action in between and, as I say, 12 to probably, I don't know, 12 to 14 starts satisfactory subsequently, if indeed the black smoke occurred, then a possible explanation is that the start sequence, for whatever reason, either human or mechanically or any other reason was not followed; such that he would get an overage start which, traditionally, on all kinds of engines creates a black smoke or a very dark smoke with the potential for some yellow flame, which is incomplete combustion where you have more fuel or you either have more fuel or less air ... it is the only explanation that I can arrive at on this particular system.
>
> I am somewhat incredulous – in fact, not somewhat, I am totally incredulous, with due respect, to the five minutes. In some training that I do, I ask people to understand ten seconds

> and so frequently they think it is five minutes. It depends on the circumstances as to your understanding of time.
>
> But I am also encouraged in this interpretation by the fact that although ... I believe, the captain on that particular occasion in the left-hand seat was reputed to have looked out three times, which in and of itself is most unusual, has no recollection of this occurrence.
>
> (Transcript, vol. 62, pp. 29–30)

Mr O'Connell's description is the only known report of an engine of the F-28 emitting an unusual amount of smoke during startup. The incident was not reported by the pilot, who, when questioned on the matter by Commission investigators, did not recall it. Engine experts could give no explanation as to why a jet engine would smoke for five minutes during startup. At times, jet engines will smoke for a few seconds during startup because of fuel pooling or incorrect startup procedures. It is considered that this incident was, at best, an isolated case and had no bearing on the serviceability of the engines and, therefore, no bearing on the accident.

Evaluation of Engine Condition

There was no material evidence of any pre-impact malfunction or failure of either engine. The left engine sustained impact damage because it struck the ground; the right engine did not strike the ground and did not sustain impact damage. Both engines exhibited similar foreign-object damage related to ingestion of tree material, and both engines exhibited similar metal spatter on internal components in the air path. This evidence indicates that the engines were subjected to approximately the same conditions at approximately the same power level during the descent into the trees.

Engine Power It was concluded by the investigators and engine experts that the engines were capable of producing full power beyond the point at which they started ingesting tree material. Indicators used by the investigators to determine the amount of power being produced by the engines are as follows:

1 The crew did not reject the takeoff. This indicates that takeoff power had been achieved and was sustained until the aircraft reached at least V_1 speed.
2 When the engines were ingesting vegetation, the bleed valves in the engines were closed, as is the case when an engine is operating at high power.

3 The metal spatter indicated, if one assumes the engines were operating normally when the compressors started to break up, that the engines were operating at or above cruise power.
4 The material temperatures in the later stages of the right engine's HP compressor were, at the time of final impact, approximately 400 C, which is the temperature of the compressor with the engine at takeoff power.
5 Although some witnesses said the engines were screaming away, or were very, very loud, or were increased to full power, none of the witnesses suggested that the engines were operating in an abnormal manner after the aircraft was airborne.

It is concluded that the engines were operating at normal takeoff power until the aircraft became airborne. After the aircraft became airborne, it is probable that the power was increased to full power.

Engine Anti-Ice The engine anti-ice valves, found in the closed position, were not damaged, and limited tests showed no faults with the valves. These valves are held open by electric solenoids when the valves are selected OPEN and if there is air pressure on the valve. When either electric power or air pressure is not available, the valves close. During the crash, the valves would have gone to the closed position; therefore, the position of the valves in flight could not be determined from an examination of the valves. From examination of the mechanical components of the system, it could not be determined whether the system was on or off. However, the presence of minute particles of organic material in the anti-ice ducting of each engine suggests that the anti-ice valves were open and that the system, therefore, was selected ON. The engine anti-ice system should have been selected ON for takeoff in the weather and airport conditions that existed at the time of the takeoff.

Auxiliary Power Unit

The F-28 aircraft is equipped with a gas turbine engine that drives a generator and a hydraulic pump. The complete unit, called an auxiliary power unit (APU), enables some aircraft systems to operate independently of ground-power sources. It is installed in the fuselage behind the rear pressure bulkhead. On the ground, the APU can provide all electrical power to all of the aircraft electrical systems and can supply air for the air-conditioning system and for engine starting. In flight, the APU can be used as a stand-by power source in the event of failure of one or both of the main engine generators.

There is a fire-detection and protection system within the enclosure for the APU. The system is automatic in that if it detects an overheat condition, it will activate the warning system, shut down the APU, and discharge its fire extinguisher. The shutdown of the APU and the firing of the extinguisher can also be accomplished by operating a manual switch in the centre of the glareshield panel. The system can be checked by operating the TEST/RESET switch on the secondary instrument panel.

The APU on C-FONF was not used on the day of the accident because the APU fire-detection circuit did not test satisfactorily. The applicable journey log entry of March 9, 1989, was, "APU will not fire test – Deferred as per MEL 49.04 – Licence ACA 87101" (Exhibit 492, appendix 17). The APU was placarded as inoperative and a main engine had to be kept running while the aircraft was on the ground in Dryden. The cause of the unsatisfactory test had not been determined prior to the accident. After the accident, there was too much crash and fire damage to the aircraft to allow the cause to be determined. The only part of the fire-detection system that remained was the fire-detection loop, housed within the APU container. A continuity check of the sensing loop found it acceptable.

The APU was sent to the manufacturer, Garrett (auxiliary power division), in Phoenix, Arizona, to verify that the unit was in an operable condition and to confirm the reported low bleed pressure during main engine start. Entries had been made in the journey log on March 4, 1989 (air pressure only 14 psi), and on March 9, 1989 (three entries: APU air pressure low, engine starts becoming more and more difficult, APU load control valve u/s), indicating that the APU was not providing adequate air pressure during start.

The APU was visually examined under the supervision of a CASB investigator. There were no abnormalities noted, except that an O-ring on the starter mounting flange was damaged; it had been damaged during removal of the APU from the aircraft. The O-ring was replaced, and the APU was started. The APU accelerated normally to the "no load" operating speed; however, the oil pressure slowly decreased until it stabilized at 30 to 35 psi. The minimum operating pressure is 70 psi, but Garrett elected to continue operating the unit to obtain a performance calibration.

On initial testing, the APU speed dropped excessively when under load, the cause of which was determined to be a malfunctioning fuel control unit. The reported low bleed pressure from the APU was exacerbated by the excessive speed drop. The fuel control unit was replaced, and the APU performance was acceptable in all respects for a unit that was in operational use.

During testing, it was discovered that the APU exhaust overtemperature thermostat either was not functioning or was misadjusted on the unit as tested. Since the malfunctioning of the thermostat did not affect the output of the APU, no troubleshooting was conducted. The oil-pressure regulator was disassembled and inspected, and the setting of the low–oil-pressure switch was verified; the cause of the low oil pressure was not determined.

Systems

The post-crash fire destroyed major portions of the aircraft, including parts of many of the aircraft systems. In general, most of the mechanical items, such as control valves and actuators, survived with limited damage, but almost all the electrical systems and electronic controls located in the area commonly called the radio bay and in the cockpit were severely burned. Although crash and fire damage precluded determining the complete state of serviceability of the aircraft, it should be noted both that critical systems are designed to be fail safe in the event of failure and that there are redundant mechanical systems.

Hydraulic System

Hydraulic power comes from two separate systems, identified in the cockpit as Utility System 1 and Flight Control System 2. Each system is identical to the other in concept and performance; they differ only in capacity, subsystems supplied, and component location. Utility System 1 supplies power to the elevator, horizontal stabilizer, left aileron, rudder, flaps, lift-dumpers, speed brakes, landing gear, normal brakes, and nose-wheel steering. Flight Control System 2 supplies power to the elevator, horizontal stabilizer, right aileron, rudder, and alternate brakes. During flight, both systems operate at 3000 psi at varying flow rates, depending on the demand for services. Each system has two engine-driven pumps and one electrically driven pump (used for maintenance only). Cockpit controls and indicators are located on the secondary instrument panel.

Reservoirs for both systems are located in the rear fuselage section immediately behind the rear pressure bulkhead. The reservoirs were undamaged but were depleted of fluid because of the rupture of the hydraulic lines during the crash.

The connector caps on the hydraulic system ground-service panel were in place, and the fluid-quantity test switch was in the proper off position. Flight-deck indicators and controls were extensively damaged, and determinations of readings and selections could not be made.

The four engine-driven hydraulic pumps were recovered in good condition, were tested, and were found to be serviceable. The electric

hydraulic pumps appeared to be in good condition but were not tested since they are not used in flight operations. The four hydraulic shutoff valves were found in the open position. These valves can be shut off from the cockpit to isolate parts of the hydraulic system in case of fire or malfunction.

The return-line filters were undamaged, and the bypass indicators were in the normal position. Under microscopic examination, an insignificant quantity of solid contaminant was observed on the filter surfaces. Hydraulic-fluid analysis revealed no fault with the fluid.

The redundancies in the hydraulic systems are such that multiple failures would have to occur to affect the operation of the aircraft systems significantly. Although major sections of the hydraulics were destroyed in the crash and fire, examination and testing of the available items provided a good indication that the total system was serviceable.

Landing-Gear System

The landing gear is a tricycle configuration, with the main gear retracting inward and the nose wheel retracting forward. There are two wheel assemblies on each landing-gear strut.

At the crash site, the left main gear was found in the down-and-locked position. The right main gear was partially retracted, and, when the fuselage was lifted during recovery, the right gear dropped to the down-and-locked position. The landing-gear doors were found at the start of the main wreckage trail. The leading edges of the main gear inboard doors showed signs of tree strikes, which indicates that the doors were open when the aircraft was contacting trees. These doors are closed when the landing gear is fully down or fully up, and the doors are open when the landing gear is in transit. The nose gear was found to be near the up position, but the uplock was not engaged.

The landing-gear–selector handle in the cockpit was found in the up position, but the position of its associated valve could not be determined.

The main landing-gear–selector valve, which is located in the hydraulic tunnel in the aircraft, was moderately fire damaged but generally intact. There is a slide within the valve that moves to either of its full travel positions, depending on whether an up or down landing-gear selection is made. The slide is held in the full travel position by the action of two spring-loaded balls. The position of the slide as found equates to an UP selection.

The forward actuator for the left main gear-door was broken away from the aircraft structure at the cylinder-end fitting. Internal examination showed marks on the cylinder wall caused by heavy side-loading of the piston while the actuator was in the fully extended position.

Examination and testing of the landing-gear system and components did not reveal any pre-impact faults.

The fact that the landing-gear–selector handle was found in the up position supports the conclusion that the gear was selected UP, and there is additional evidence for such a conclusion. As well, the lever could have been moved to the up position by the loads placed on the gear-selection linkage during the breakup of the aircraft. The most definitive evidence showing that the gear had been selected UP was the position of the slide in the main gear-selector valve. The design of the ball and detent system is such that the position of the slide should not be affected by crash forces. Accordingly, it is concluded that the gear was moving to the up position at the time of the accident.

Wheels and Wheel-Brake System

The tread on the four main tires was good, and there were no flat spots or evidence of hydroplaning. The wheels showed no signs of overheating, and the fusible plugs in the wheels were in place, with no signs of rupture. There was no evidence that any of the wheel bearings suffered rolling-element distress.

All four brake units remained intact. The right and left outboard brakes were within the in-service wear limits; however, the right and left inboard brakes were worn beyond the specified limit. The Fokker F-28 Engineer's Guide, under the heading "Wear Check for Mounted Brakes," shows a maximum dimension of 0.250 inch from the face of the outer spring-holder to the tip of the return pin, with brakes applied. Both left and right inboard brakes measured 0.290 inch but were assessed as still being operational. Although two sets of brakes were worn beyond specified limits, the CASB investigation team assessed the brakes, tires, and wheels as having been in a serviceable condition at the time of the crash.

Electrical System

The aircraft is equipped with AC- and DC-operated systems, with the electrical power, when required, supplied through electrical buses by a battery, two engine-driven AC generators, an APU-driven generator, and an AC ground-power unit (external power).

The AC bus arrangement is such that one particular bus is supplied by one electrical source at a time. In case the source becomes inoperative, the bus is automatically transferred to another source. The DC buses are supplied by transformer-rectifier units (TRUs), which in turn are supplied from the AC buses. When a TRU becomes inoperative, the DC bus can, in some cases, be transferred to another TRU. The battery is for starting the APU and, in case of an emergency, is the last source of electrical power.

The aircraft electrical system was extensively damaged by the crash and fire, and examination of the wiring and components was therefore limited. From what was found, the only evidence of malfunction in the electrical system was a fault in the left generator.

The main frame of the number 1 (left) generator was cracked, and full functional testing was not possible. Testing confirmed that the rotor windings were in good condition, although there was an open circuit in the rotating rotor assembly. Significantly, two wires from diodes to the main rotating field were broken. Fracture analysis showed that the first wire had been broken for some time; in this condition, the generator would continue to produce power but, short of providing its full-rated load, would break down. There is no indication that an abnormally high load was placed on either generator. Based on the capacity of the generator to continue to operate with one wire broken as long as there is no unusually high load placed on it, and on the fact that the analysis showed that the break was not new, it is probable that the wire was broken prior to the accident flight.

The fracture of the second wire would have resulted in output failure of the generator. The break in this wire showed evidence of arcing. Its fracture surface was not as contaminated as that of the break in the first wire, indicating a more recent failure. It is probable that this break was related to the impact forces which caused the external damage to the generator, but it cannot be stated conclusively that the wire was not broken prior to the crash.

In the event of a generator failure, the relevant GENERATOR INOPERATIVE light will illuminate, and automatic transfer of the load will take place. The operating procedures specify that should a generator fail at some point during the takeoff, no crew action is required prior to establishing a normal climb configuration. Because of redundancy in the electrical system, multiple faults are unlikely and individual faults would have no significant effect on the aircraft's operation. Therefore, it is concluded that electrical failure, even in the improbable event that it did occur, did not likely contribute to the crash.

Fuel System

The fuel system controls in the cockpit and the left-wing fuel system components were not recovered because of the fire and impact damage. The integral fuel tanks were ruptured in the crash, all of them subjected to some degree of fire damage.

The two booster pumps from the right fuel tank were recovered and tested; they operated satisfactorily. The canister shutoff valves and vent valves were open, and the tank internal plumbing in this area was in good condition. Debris found on the surface of the intake screens was typical of miscellaneous contaminants found in fuel tanks, and the

quantity would not have significantly affected fuel entry to the pumps. The fuel system's left and right fire-shutoff valves were open, and both cross-feed valves were closed.

The open fire-shutoff valves and the closed cross-feed valves show that the fuel system was configured as would be a serviceable fuel system. Evidence of proper operation is reflected in the findings that both engines were running at the time of the crash and the cross-feed valves were closed.

Fire-Protection System

An independent fire-detection and protection system is installed in the aircraft for each of the left and right engines and for the APU. Each system consists of a detection system and an extinguishing system. The detection system consists of a sensing element loop in each engine nacelle and in the APU enclosure, and a warning system of lights and audible alarms in the cockpit. Three fire-extinguishing–agent containers installed in the tail section supply extinguishing agent to the two engines and the APU. There are three portable carbon dioxide fire extinguishers in the aircraft, one in the cockpit and two in the cabin, and there is one water/glycol fire extinguisher in the cabin.

The engine fire-protection–system controls in the cockpit were destroyed by the post-crash fire and were not recovered. The sensing element loops in the engine nacelles had been subjected to some impact damage but were generally in good condition, and no pre-crash faults were noted.

The three fire-extinguishing–agent containers were found intact. None of the cartridges from any container had been fired, and all of the outlet discs were intact. The left container safety disc in the thermal discharge fitting was ruptured, and the container was empty; there was evidence of exposure to the fire, but there was no significant damage to the container. The right container and the APU container were still charged with gauge readings of approximately 600 and 575 psi, respectively. It was concluded that the fire-extinguishing system had not been activated by the flight crew.

Impact and fire damage precluded testing of the fire-protection system to determine pre-crash integrity. There was no evidence of fire prior to impact.

Bleed-Air Supply System

Bleed air supplies the following systems: air-conditioning and pressurization, airfoil anti-icing, engine anti-icing, engine starting, and hydraulic reservoir pressure. The air can be supplied from the main engine compressors and, on the ground, by the APU or a pneumatic high-pressure ground-power unit.

The pneumatic system valves and ducting in the engine pylons and in the rear fuselage section were in good condition. The shutoff and pressure-regulating valves and the shutoff and pressure-modulating valves are electropneumatically operated and are spring-loaded to the closed position; all four of the valves were closed.

Ice- and Rain-Protection Systems

To prevent the buildup of ice in the main engine air intakes and on the leading edges of the wings and the horizontal and vertical stabilizers, hot compressed air from the bleed-air supply system can be directed to these areas by cockpit controls. The windshields, the sliding windows in the cockpit, the angle-of-attack vanes of the stall-protection system, the static ports, and the pitot tubes of the air data indicators are electrically heated to prevent ice accumulation. An ice-detect probe under the aircraft's nose section detects ice in flight. The aircraft is equipped with windshield wipers for operation in rain.

All the cockpit controls and indicators for these systems were destroyed in the fire. The ice-detect probe was found in relatively good condition, and both its detection and heating systems tested satisfactorily. The airspeed pitot head from the left side of the aircraft was impact damaged, but the heater circuit was still functional. The pitot head from the right side was not recovered. Both angle-of-attack sensors were recovered, but they were too severely damaged to permit an assessment of the condition of the heaters.

The wing anti-ice valve and the tail anti-ice valve were recovered in good condition. They are motorized butterfly valves, electrically operated, and both were found in the closed position. When tested, the valves operated satisfactorily; the wing valve moved from open to closed or closed to open in approximately 5 seconds, and the tail valve moved in approximately 5.7 seconds.

The finding of the wing and tail anti-ice valves closed is a good indication that the wing and tail anti-ice system was off at the time of the takeoff. As the aircraft takes off or lands, switches on the lower portion of each of the main landing-gear struts direct some aircraft systems, such as touchdown protection for the wheel brakes, landing gear anti-retraction solenoids, and the wing lift-dumpers, to operate in a specific manner. The switches are called "ground/flight switches" by Fokker Aircraft. When the aircraft is on the ground, the ground/flight switch prevents normal opening of the wing and tail anti-ice valves. Thus, if the wing and tail anti-ice system is selected ON while the aircraft is on the ground, the valves will remain closed until the aircraft becomes airborne and the switch indicates that the aircraft is in the air. The crew would then have had to assess the situation and select the system OFF. The valves would then have had to move to the closed

position while there was still electrical power available. It is deemed unlikely that there would have been sufficient time for this sequence to have occurred. It is improbable as well that the valves went full closed as a result of intermittent electrical shorts during the aircraft breakup. During use, the wing and tail anti-ice system bleeds air from the engine compressors, a process that results in a significant engine performance penalty; therefore, the wing and tail anti-ice system is not used during takeoff. This penalty would be felt just as the aircraft becomes airborne. To open the wing and tail anti-ice valves while the aircraft is on the ground, a test switch located behind the co-pilot's seat must be positioned to ANTI. IC. L.G. OVERR. (anti-ice landing-gear override) and held there. When the switch is released, the valves are powered to the closed position.

Air-Conditioning System

The air-conditioning system control panel and the right-side refrigeration unit were destroyed in the post-crash fire. The left-side refrigeration unit, which supplies conditioned air to the cockpit, sustained some impact damage but was untouched by fire and remained relatively intact. Although the unit could not be tested, visual examination revealed it to be in relatively good condition.

Instrument Systems

The left-side (captain's) flight instruments were almost completely destroyed by fire. The engine instruments and the right-side (first officer's) instruments were relatively intact, but many of the instruments had returned to a zero reading with the loss of input signal. The impact damage had not been severe enough to freeze pointers in position, to capture any pointer imprints, or to damage any of the gear trains; thus, reliable indications of the instrument readings at impact could not be obtained from a study of the impact damage.

Examination of the instruments revealed the following:

1 The right-side airspeed indicator "bug" was set at 132 knots indicates the calculated V_1 speed.
2 The left- and right-engine thrust-meter index displays, which indicate the calculated power settings for setting takeoff power, were both set to a value of 166.
3 The left and right fuel-quantity indicators were reading 5400 and 6950 pounds, respectively. The difference may have been as the result of the loss of fuel from the left wing, which was breaking up during the crash; the gauge was reflecting the loss until electrical power was lost to the gauge.

4 The left and right fuel-consumed indicators were reading 2078 and 2091 pounds, respectively. It was reasoned that, for the numbers to make sense, the gauges had last been reset to zero at Thunder Bay.
5 The left and right fuel load–limit indicators, normally located in the refuelling access area on the underside of the right wing, were set to 7200 and 6800 pounds, respectively. These numbers would normally be the same. On the right instrument, the set knob was somewhat displaced from the needle, which could account for the difference in the settings.

The static ports from the right side of the fuselage were severely fire damaged, with the lines from the ports inboard of the connecting nuts burned away. All portions of the navigation system instrumentation were either consumed or too badly damaged by fire and impact to allow an assessment of serviceability.

Indicator Lights

A study of the annunciator and other indicator lights was conducted by Mr James Foot to determine if any of the lights was illuminated at impact, which in turn would give an indication of the status of the lights associated with that system. Mr Foot is an electrical/mechanical analyst employed by CASB and working at the CASB engineering laboratory in Ottawa. A certified electrician, he has a diploma in chemical technology and a bachelor's degree in mechanical engineering. Mr Foot prepared a report on his study of the lightbulbs and filaments, which was entered as Commission exhibit 441, and he gave testimony on this subject at the Commission hearings.

The examination entails a microscopic inspection of the bulb filaments for stretching, distortion, coloration, and types of failure. Normally, when shocked, an incandescent filament will exhibit deformation of the coils in the form of stretching or uncoiling, and the filament may or may not be fractured. A fractured filament without deformation is normally associated with a cold shock, since the tungsten fails in a brittle manner. Cooldown for a "hot" filament to a "cold" filament, which occurs with the loss of electrical power, takes place in less than 50 milliseconds for a typical lightbulb or lamp.

A total of 117 lamps were examined, 21 of which had fractured filaments. Nine of the lamps with fractured filaments were from the landing-gear–position indicator. Two of the lamps from that indicator – the service door light and the right main landing-gear red light – exhibited a small amount of localized stretching, although not enough to allow a conclusion that either or both lamps were on at impact. The observation that 21 filaments were considered to have fractured when cold indicates that localized g forces (impact forces) were significant. It

was reasoned that had any lamp filament been incandescent (on) during the crash, the g forces were sufficient to have caused filament distortion, thus identifying those filaments that were incandescent. However, this theory assumes that electrical power was still available to the lamps when the impacts occurred.

It was concluded that one lamp from the number 1 constant speed drive (CSD) annunciator was illuminated when its envelope cracked, but it could not be determined whether the envelope was cracked during the accident or prior to it. All the other lamps exhibited signs of being off at impact, which is not to say that they all should have been off. Lamps could have shown signs of being off because the local impact forces were low or because of the loss of electrical power prior to impact.

The CSD on each engine connects the generator to the engine and drives the generator at a constant speed of 8000 rpm, irrespective of changes in engine operating speed and/or electrical load. The CSD warning light will illuminate if there is low oil pressure, if the oil overheats, or if there is a reduction in CSD speed. It is possible that the light illuminated during the crash when the engine speed became too low to operate the CSD at a constant speed.

Radio and Navigation Systems

There is no evidence that communication radios or navigation radios and systems were of significance in this accident. All the radios and other cockpit-located components were burned and could not be tested. The last radio transmission from the aircraft occurred just before the takeoff commenced, indicating that the communications radio was functioning. It is highly unlikely that the failure of any navigation equipment would have contributed to the crash.

Flight Controls

Many of the component parts of the flight control systems were recovered, and examination, testing, and assessment of these components did not indicate any pre-crash fault or unserviceability. All the fractures were identified as impact overload in nature, with no evidence of fatigue or other premature failures. The considerable crash and fire damage to the flight control systems, particularly from the cockpit to the centre wing area, precluded a complete analysis of the pre-crash serviceability of each system.

Primary Flight Controls

The primary flight controls consist of the ailerons located on the outboard trailing edge of each wing, the rudder hinged to the trailing edge of the vertical stabilizer, and the elevator located at the trailing

edge of the horizontal stabilizer. The controls are hydraulic powered, and all have mechanical backup systems. There was nothing found during the investigation that indicated the primary flight controls were not fully serviceable.

Gust Locks Mechanical gust locks can be engaged on the ailerons, elevators, and rudder to prevent the wind from damaging these components when the aircraft is parked. All the locks are operated by a single control in the cockpit; to allow engagement, the ailerons and rudder must be centred and the elevator trailing edge must be full down. The elevator gust lock was not engaged when examined after the crash, and it operated freely. The mounting bracket for the rudder gust lock was broken as a result of overload transmitted through the gust-lock operating cable during breakup of the aircraft. There was no evidence to indicate that the rudder lock was engaged at the time of impact.

In addition to the physical evidence, there is other evidence that the gust locks were not engaged during the takeoff: the pilots in all likelihood performed a flight control check prior to takeoff, which could not be accomplished with the locks engaged; there is an interlock system that prevents forward throttle movement when the gust-lock control is in the engaged position; and the aircraft was rotated during takeoff (evidence that the elevator was free to travel).

Secondary Flight Controls

The secondary flight controls consist of the wing flaps, lift-dumpers, and speed brakes. The controls are hydraulic powered, and the flaps have an electrical backup; there is no backup system for the lift-dumpers or speedbrakes. There was nothing found during the investigation that indicated the secondary flight controls were not fully serviceable.

Wing Flaps The wing flaps are located at the trailing edge of each wing, between the ailerons and the fuselage. From examination and measurements of the flap actuators and from the position of the cam shaft, which operates the flap control switches, it was determined that the flaps on both sides of the aircraft were between 25° and 27° extended at the time of the crash. The cockpit controls were destroyed in the fire, and the selected flap position could not be determined. According to Captain Berezuk, who was seated in seat 12A, the flaps were set at 18° prior to commencement of the takeoff. This setting would be normal for the conditions of the takeoff. (The fact that the flaps were found positioned at 25° to 27° will be discussed in chapter 12 of this Report, Aircraft Performance and Flight Dynamics.)

Lift-dumpers The lift-dumpers are installed on the upper surface of each wing's inboard half, in front of the wing flaps, and are used to reduce the landing roll of the aircraft. The damage to the lift-dumper controls and the hydraulic manifold precluded any determination of the selected lift-dumper position. System analysis was limited to tests of hydraulic actuators (to establish serviceability) and to an examination of damage to the linkage and lift-dumper surfaces (to determine the actual position of the surfaces at the time of the aircraft's breakup). The damage patterns on the lift-dumpers and the surrounding fixed portions of the aircraft clearly show that the lift-dumpers were in the closed (retracted) position at the time of the crash, and there is no evidence that the lift-dumpers were deployed at any time during the takeoff. The cockpit lift-dumper controls were not recovered.

Speed Brakes The speed brakes are hinged on either side of the tail cone. The complete speed-brake assembly was torn from the aircraft during the crash. Examination and testing of the recovered components did not reveal any significant discrepancies, and there was no evidence to support a definitive finding as to speed-brake position during the flight or during the time of impact with the trees. The damage to the speed brakes shows they were in the closed position at the time of ground contact. The cockpit control was not recovered. When the throttles are advanced for takeoff, or to the detent, an electrical signal is given to the hydraulic actuator to close the speed brakes, and the control lever is moved by spring force to the in position.

Supplementary Flight Controls

The supplementary flight controls include trim controls for the aileron and rudder, the adjustable horizontal stabilizer, and the automatic pilot system. There was nothing found during the investigation that indicated the supplementary flight controls were not fully serviceable.

Trims Trimming of the ailerons and rudder is accomplished mechanically by rotating trim knobs on the pedestal to alter the neutral positions of springs within the control systems. Longitudinal trim is provided by adjusting the entire horizontal stabilizer. The horizontal stabilizer, which is hydraulic powered, is controlled by trim wheels in the cockpit connected with a cable system to the control unit's input mechanism. In case of hydraulic failure, stabilizer deflection can be accomplished with an electric motor controlled by a switch on the pedestal.

During the investigation, it was noted that the screwjack of the rudder trim system was slightly out of the neutral position in the direction of deflecting the rudder to the left. The position of the rudder trim setting as found is not a good indication of the setting prior to aircraft breakup.

When one control cable breaks, the other will usually pull and turn the drum to a new position before overloading fails the second cable. From the index mark painted on the vertical stabilizer, the horizontal stabilizer setting was at $-1.5°$ after impact. It was determined from the Fokker F-28 Flight Handbook that, for takeoff, the horizontal stabilizer should be set at between $+2°$ and $-2°$, depending on the centre of gravity of the aircraft; therefore, $-1.5°$ would be a normal setting for the takeoff. The locking feature of the redundant electric drive system in the horizontal stabilizer actuator will retain the stabilizer surface in position when hydraulic pressure is lost, and there is reasonable confidence that $-1.5°$ was the setting prior to impact. The position of the aileron trim could not be determined.

Autopilot The autopilot is an electromechanical system that provides flight stabilization and manoeuvre control in the three aircraft control axes, namely yaw, pitch, and roll. The autopilot can be coupled to the VHF navigation and flight systems.

Although it would not be expected to have the autopilot on during takeoff, the possibility of inadvertent engagement or seizure of the clutch mechanism in a critical component, such as the elevator or the stabilizer, was considered. Unfortunately, the autopilot computers were destroyed in the fire, leaving only the servo units available for examination. Examination and testing revealed no faults other than those that were crash related.

The stabilizer position after impact indicates the probability that no "runaway" of the trim or autopilot system occurred during the takeoff. Failure of the trim to move from the preset position, if such had occurred, should not have been a significant problem for the pilot. The possible result of a failure in the elevator autopilot control is less certain. However, since no fault was found in the autopilot servo clutch, the pilot would have had no problem overriding any spurious output to the elevator controls.

Flight Data Recorder/Cockpit Voice Recorder

The aircraft is equipped with a flight data recorder (FDR) and a cockpit voice recorder (CVR). In normal operation, the FDR in C-FONF would record 19 parameters, with indications of aircraft heading; speed; attitude; altitude; acceleration; engine thrust; positions of the control column, control wheel, and rudder pedal; pitch trim position; and whether the autopilot and pilot's radio key are on or off. The CVR records all conversation and noise within the cockpit and radio conversations with outside agencies.

Both the FDR and the CVR were located and recovered by a member of the investigation team approximately 24 hours after the crash. On March 11 CASB investigator David Adams located the recorders in the expected area – near the right rear cargo entry door in front of the rear pressure bulkhead, but buried in debris. The recorders were delivered by CASB investigators to the CASB engineering laboratory in Ottawa at 8 p.m., March 11, 1989. The FDR was determined to be a Sundstrand UFDR (universal flight data recorder), and the CVR was determined to be a Sundstrand Model V-557.

It is a matter of concern that the crash, fire-fighting, and rescue (CFR) unit at Dryden did not have a chart of the F-28 aircraft depicting the locations of important safety-related items. This type of chart, commonly referred to as an aircraft crash chart, is essential in assisting fire-fighters to locate items such as batteries and oxygen bottles, which pose a danger to themselves or others, or objects such as the recorders, which provide information vital to the safety of future travellers. It is absolutely essential that every airport CFR unit have a crash chart available for each type of aircraft that commonly frequents its airport, and that all unit personnel have a good understanding of the charts.

Data Recovery

The recorders on C-FONF suffered extensive fire damage but generally sustained little impact-related damage. The fire had destroyed the normal fasteners, and both recorders had to be cut open; a pneumatic cutoff wheel was used to minimize further damage to the storage medium. On disassembly, it was discovered that the recording medium (one-quarter-inch mylar tape) of both recorders had essentially been destroyed by severe heat damage. There was no practical way to recover the analog information from the CVR tape remnants. Attempts at partial recovery of the digital information on the FDR tape remnants, using optical and scanning electron microscopes, were not successful. No data were recovered from either recorder.

Because no data from the recorders were available to allow determination of the flight profile or to indicate the conversations that took place in the cockpit, it was necessary to conduct a highly detailed investigation into the events that took place during the final minutes of the flight. Unfortunately, because of the lack of information from the recorders, some details about the flight will never be known.

Fire Damage Analysis

Representatives from the manufacturer, Sundstrand Data Corporation, assisted in the investigation in an attempt to determine the temperatures endured by the crash-protected enclosure of the FDR. Sundstrand conducted a series of elevated temperature tests, for various durations,

on a tape transport of identical construction to that recovered from C-FONF. It was determined from damage comparison that the FDR from C-FONF was subjected to a flame at an assumed temperature of 1100°C for 1.5 hours. Then, based on the review of the C-FONF FDR metallurgical information provided by CASB, the estimate was refined to exposure to an average temperature of 850°C for a period in excess of two hours.

Fire Survivability

Flight recorder regulations in place on March 10, 1989, are contained in the United States Federal Aviation Administration (FAA) Technical Service Order C51a (TSO-C51a), the standard for flight recorders, which has been adopted by Canadian authorities for Canadian-registered aircraft. The regulations require that flight-recording devices withstand a temperature of 1100°C for 30 minutes with 50 per cent of the recorder enclosed in flames. Discussions between CASB investigators and personnel from the FAA and Sundstrand, and a review of the documentation regarding the certification tests, confirmed that both recorders in C-FONF met the specifications contained in TSO-C51a.

An international working group, the European Organization for Civil Aviation Equipment (EUROCAE), is endeavouring to bring about changes to the regulations for flight recorders. The Transportation Safety Board of Canada (TSB) is a member of the organization. A more rigorous fire test for the next generation of flight recorders was developed at a EUROCAE meeting in May 1989. The proposed new specification is still based on 30 minutes at a temperature of 1100°C, but with 100 per cent of the recorder enclosed in flames rather than 50 per cent, and with a thermal flux (heat transfer) of 50,000 BTU per square foot per hour. The increase in the flame coverage and the addition of the thermal flux parameter ensure that the test represent a severe fire; the current test is non-uniform and interpretive. The general feeling in the recorder community is that the addition of the thermal flux requirement makes the test twice as severe. The specifications recommended by EUROCAE are contained in two documents: "ED55 – Minimum Operational Performance Specifications for Flight Data Recorder Systems"; and "ED56 – Minimum Operational Performance Specifications for Cockpit Voice Recorder Systems."

With current technology, an increase in the duration of the fire test in addition to the thermal flux requirements would require increased insulation and thus a larger box in which to house the recorder. Since it is undesirable to increase the size of the box, industry representatives at the May 1989 meeting were generally opposed to an increase in the test duration, although the accident investigation community, and Canada in particular, expressed a strong interest in both an increase in the test duration and the addition of the thermal flux parameter. In the interest

of preserving this most valuable investigative tool, I recommend that the TSB continue to press for the adoption of more rigorous test requirements for data recorders.

Location of Recorders

The recorders in the F-28 aircraft are normally located just in front of the rear pressure bulkhead. This area of C-FONF, which was pressurized, suffered extensive fire damage in the crash, whereas the area behind the bulkhead, which was non-pressurized, was undamaged by fire. It was noted by the investigators that if the recorders had been located in this non-pressurized area, they likely would not have been fire damaged and therefore would have yielded useful information.

Recorders are certified to endure the temperature, humidity, and environmental conditions in non-pressurized areas of aircraft; however, locating recorders in these areas is generally viewed as undesirable because of increased maintenance concerns. Current recorders are essentially tape drives with many mechanical parts, prone to serviceability problems in hostile environments. Although locating recorders in non-pressurized areas may result in less chance of damage in a crash or fire, the recorder may not be serviceable when required because of its exposure to the elements. Further study of recorders and their locations, correlated to maintenance history, would be helpful for assessing the relative desirability of locating recorders in non-pressurized areas. Solid-state recorders may increase the commercial acceptability of locating recorders in non-pressurized areas.

Solid-State Recorders

Solid-state FDRs are now operating on some aircraft in North America, and solid-state CVRs are in the process of being certified; they will be operating on aircraft in late 1991. Data for both recorders are stored in computer chips; there are no moving parts. It is possible to record almost 300 parameters on present magnetic-tape FDRs. Existing solid-state FDRs have about the same capacity, although some solid-state FDRs with double that capacity are now being offered on the Airbus A320 and the new Boeing 777. Solid-state CVRs can record from 30 to 120 minutes by having memory modules added to them. In December 1990 the cost of 120 minutes of memory was predicted to be about U.S.$50,000.

Modern electronic aircraft have thousands of parameters on their electronic buses, and FDRs on these aircraft are able to save data of a quality and quantity that has not been previously available. Based on recent TSB experience working with the tape recorders from A320 aircraft involved in occurrences, the FDRs and CVRs contain enough information to provide detailed accounts of the occurrences. The use of

solid-state recorders, with their ability to store greater amounts of more reliable data, will improve on the capability of data recorders and undoubtedly be of greater benefit to everyone who has a use for the data, particularly those involved in accident investigation.

The manufacturers of solid-state recorders are building recorders to meet the EUROCAE specifications as detailed in publications ED55 and ED56 with regard to fire and heat, water submersion, and impact and acceleration forces. At the time of publication of this Report, these specifications were not law in any country; however, it is anticipated that the specifications will be universally adopted. It is also believed that, because solid-state recorders have no moving parts, the recorders will be better able to withstand the environment in the non-pressurized areas of aircraft. The solid-state recorders are the same size as the most popular magnetic-tape recorders in service.

Flight Path Reconstruction

In support of the overall investigation, the CASB engineering laboratory constructed three-dimensional flight path models, using computer-generated imagery. Information for such modelling is normally obtained directly from flight data recorders. Since the recorders from this accident were destroyed by fire, the information had to come from other sources. These sources included eyewitnesses, wreckage distribution, photographic evidence, survey evidence, tree-strike evidence, a model of the F-28 aircraft, past flight recorder data from this very aircraft, and some assumptions based on an understanding of the way aircraft fly. It is important to note that the reconstruction depicts an approximation of the aircraft's flight path and behaviour; the results are qualitative and were not, and should not be, used for quantitative analysis. From an analysis of the reconstructed flight path, the aircraft did not exhibit any unusual yaw, pitch, or roll prior to impact. This finding agrees with the conclusions reached related to aircraft damage assessment and aircraft attitude.

Aircraft Weight

The maximum structural gross takeoff weight of the Fokker F-28 Mk1000 aircraft is 65,000 pounds. Before taking off from Dryden on the accident flight, the crew of C-FONF did not leave a completed weight-and-balance form with the company agent, as required. As part of the calculations used to estimate the weight and centre of gravity of the aircraft at takeoff, the investigation team's operations group reviewed passenger and baggage weights used by Air Ontario, Air Canada, and Canadian Airlines International Ltd (CAIL) as well as those included in

the Transport Canada–issued A.I.P. Canada: Aeronautical Information Publication, TP 2300E.

In determining aircraft takeoff weight and centre of gravity, Air Ontario F-28 flight crews normally use a winter weight of 169 pounds per passenger and a baggage weight of 23.5 pounds per bag. Air Canada uses winter weights of 193 pounds for males and 146 pounds for females, arriving at an average winter weight of 178 pounds, and a per bag weight of 26 pounds. CAIL uses 28 pounds per bag. The A.I.P. dated October 20, 1988, contains weight calculation data extracted from an airline/Transport Canada survey, with winter weights of 188 pounds for males and 141 pounds for females and an average weight of 164.5 pounds. These passenger weights include exterior clothing and articles of carry-on baggage. Using the above passenger and baggage weights and other relevant information, the operations group calculated that C-FONF weighed between 62,600 and 64,800 pounds when it commenced its takeoff roll prior to the crash.

Airworthiness of C-FONF

As part of the investigation, the maintenance records of C-FONF were reviewed in detail to determine the manner in which Air Ontario was operating and maintaining the aircraft and to ascertain whether the aircraft was being operated and maintained in accordance with the *Aeronautics Act*, the Air Regulations, the Air Navigation Orders (ANOs), and Transport Canada policies.

Applicable Legislation and Regulations Effective March 10, 1989

Section 4 of the *Aeronautics Act*, as amended, makes the minister of transport, or such other minister as designated by the Governor in Council, responsible for the development and regulation of aeronautics within Canada and applies to all aircraft operations within Canada. Section 4 of the Act authorizes the Governor in Council at the request of the minister to make regulations and orders for such development and regulation of aeronautics. Subsection 4.9 is a broad section giving the Governor in Council general powers to make such regulations as necessary, including licensing of persons involved in aeronautics and the conditions under which aircraft may be utilized and operated within Canada.

Part II of the Air Regulations, Consolidated Regulations of Canada, deals with Canadian aircraft registration, airworthiness certification, and markings of aircraft. The documents that govern airworthiness certifi-

cation and standards for aircraft and aeronautical products in Canada are the United States Federal Aviation Regulations, and the Canadian airworthiness manual and engineering and inspection manual. Sections 210 through 221 of the Air Regulations deal with aircraft certification and airworthiness and provide the minister with the powers to ensure that he or she is satisfied that an aircraft operating in Canada "conforms to the applicable standards of airworthiness or is of a design in respect of which a type approval has been issued" or a "certificate of airworthiness in respect of that aircraft" has been granted (s. 211(2)). The Air Regulations empower the minister to make such orders or directions in the form of Air Navigation Orders (ANOs) relating to, among other things, the aeronautical design, airworthiness, approval, and operation and use of aircraft and aeronautical products in Canada.

Certification

Certification Requirements

Before an aircraft can be operated commercially in Canada, the operator must meet certain conditions. With regard to certification, the operator first must apply for and be granted a certificate of airworthiness (C of A) and then must maintain the aircraft in accordance with applicable regulations.

From the Department of Transport Certificate of Airworthiness/Flight Permit Application Form 26-0024 1-77 Amended by AL 24 (not verbatim):

> The operator must submit to the Department of Transport an application for a certificate of airworthiness for an aircraft. The application clearly identifies the aircraft and contains the following affirmations: that the aircraft conforms with the Aircraft Type Approval or Type Certificate Number and is airworthy; that the aircraft has been inspected and on the date of inspection was serviceable; that the aircraft was flown and found to meet the standards; and, that all applicable DOT airworthiness/serviceability requirements have been complied with.

The following is from the Air Regulations:

> 211.(2)
> The Minister shall, on being satisfied that an aircraft conforms to the applicable standards of airworthiness or is of a design in respect of which a type approval has been issued and is still current, issue a certificate of airworthiness in respect of that aircraft.

The following is from ANO Series II, No. 4:

Conditions of Certificate of Airworthiness

3. Every certificate of airworthiness issued in respect of an aircraft is issued on condition that
   (a) the aircraft will be maintained is accordance with a maintenance program that meets the aircraft standards of airworthiness established by the Minister pursuant to section 211 of the *Air Regulations*, and
   (b) an entry will be made in the Aircraft Journey Log of the aircraft by an authorized person, certifying that the aircraft is
      (i) airworthy, or
      (ii) released to service,
      whichever is applicable, at the times and in accordance with the procedures set out therefor in the *Airworthiness Manual* or in the *Engineering and Inspection Manual*.
5. Notwithstanding anything in this Order [ANO Series II, No. 4], a certificate of airworthiness issued in respect of an aircraft is not in force at any time when either of the conditions set out in paragraph 3(a) or (b) fails to be satisfied in respect of that aircraft.

Transport Canada inspectors Randy Pitcher and Ole Nielsen both testified that the certificate of airworthiness of an aircraft is void (that is, invalid) if there is any essential aircraft equipment unserviceable and the defect has not been deferred with respect to the approved minimum equipment list (MEL) for the aircraft. This subject is dealt with in greater detail later in this chapter.

Canadian Certification History of C-FONF

On May 6, 1988, a "Certificat de Navigabilité pour Exportation" (certificate of airworthiness for exportation), number 14638, was issued for the aircraft by the minister of transport for the Republic of France. Typed on the certificate was, "The airplane identified by this Certificate has been examined and found to conform to Canadian Type Approval No. A-108." Aircraft type approval A-108 was issued by the Department of Transport on February 27, 1973, with respect to the Fokker F-28 Mk1000 (approved August 3, 1972) and Mk2000 (approved August 30, 1972) aircraft.

Transport Canada issued a provisional certificate of registration (C of R) and flight permit for C-FONF on May 11, 1988, which allowed Air Ontario to fly the aircraft from France to London, Ontario. On May 19, 1988, Transport Canada issued a C of R for the purpose of private operation, and on June 10, 1988, it issued a C of R for the purpose of commercial operation. A further C of R was issued June 13, 1988. (It

appears a typographical error was made; the June 10 C of R stated F28 MK100, whereas the June 13 C of R stated F28 MK1000.)

A certificate of noise compliance for the aircraft was issued May 26, 1988.

The application for the issue of the Canadian C of A was made under company approval number ACA 57078 (May 18, 1988). A Canadian C of A in the "standard" category was issued May 30, 1988, by Transport Canada after an inspection of the aircraft in London, Ontario, by a Transport Canada inspector.

The Air Ontario Maintenance Control Manual was amended to include reference to the F-28 aircraft. The amendment (no. 3) was approved by Transport Canada on June 3, 1988.

Letter of Approval

A letter of approval, dated March 22, 1989, 12 days after the crash at Dryden, was sent by Transport Canada (Aviation Regulation), London, Ontario, to Air Ontario; on it the Fokker F-28 had been added to the list of aircraft that Air Ontario was authorized to maintain. In testimony, Ms Elaine Summers, CASB chairwoman of the investigation's records and documents group and formerly a Transport Canada airworthiness inspector, stated that a letter of approval would normally be issued at the time the company maintenance control manual amendment regarding a new aircraft is approved, in this case June 3, 1988. In testimony, Mr Nielsen stated that the operating certificate is not predicated on the issuance of a letter of approval. The letter of approval is without basis in legislation, and the authority for a company to maintain an aircraft type is in the approved maintenance control manual.

Airworthiness Staff Instruction, File No. ARD 5009-003-33, Air Carrier Approvals, Audits and Surveillance, was issued by the acting director, Airworthiness Branch, Transport Canada, on July 20, 1987. The purpose of the instruction was to establish the national standards for air carrier certification, audits, and inspections. The instruction contains some information regarding the letter of approval and a sample of the letter. Part II, paragraph 1.3.4, "Issue of Company Approval," states: "Upon being satisfied that the Air Carrier meets all of the Transport Canada requirements, the RMA [regional manager (airworthiness)] may issue a Letter of Approval" (Exhibit 494, p. 18). It is not stated in the instruction that issuance of the letter is a requirement for operation of the aircraft by the company. In order to obviate the ambiguity of the instructions regarding the requirement for a letter of approval, I urge that the issuance of the letter be made mandatory as an indication that Transport Canada is satisfied that the applying air carrier has met all Transport Canada requirements.

Minimum Equipment List

Most large aircraft are designed and certified with a significant amount of redundancy in their systems so that the minimum standards of airworthiness are satisfied by a substantial margin. A minimum equipment list (MEL) is an alleviating document that regulates the dispatch of an aircraft with inoperative essential aircraft equipment. Basically, compliance with an MEL allows an operator to defer repair or maintenance and fly an aircraft without all the essential equipment operative in order to complete a flight segment, or until repairs can be made. Compliance with an MEL is accomplished through one or more of the following means: adjusting the operating limitations to provide an equivalent level of safety; transferring functions or referencing other operating components; changing the operating procedures; or changing the maintenance procedures. A fundamental understanding is that the continued operation of an aircraft with inoperative essential equipment should be minimized. In Canada, MELs are prepared by the operator and approved by Transport Canada.

Essential aircraft equipment is defined in ANO, Series II, No. 20, section 2 ("Interpretation") as follows:

> "essential aircraft equipment" means an item, component or system installed in an aircraft, that
> (a) has a primary role of providing information or performing a function required by regulation or order; or
> (b) is directly related to the airworthiness of the aircraft;
>
> (Exhibit 311, p. 1)

It is a matter of concern that during the testimony of many witnesses, no one, including commercial pilots and Transport Canada employees, found the definition of "essential aircraft equipment" to be readily usable or useful to pilots and technicians during normal aircraft operations. I will discuss this lack of a useful definition of essential aircraft equipment in detail in chapter 16 of this Report, F-28 Program: APU, MEL, and Dilemma Facing the Crew.

Air Navigation Orders, Series II, No. 20, sections 4, 7, and 8, state as follows:

> 4. An air carrier may submit [to Transport Canada] for approval a minimum equipment list for each type of aircraft that he operates.
> 7. No air carrier shall operate an aircraft if any essential aircraft equipment is inoperative unless he does so in compliance with a minimum equipment list.

> 8. Notwithstanding section 7, no aircraft shall be operated where, in the opinion of the pilot-in-command, flight safety is or may be compromised.
>
> (Exhibit 311, p. 2)

From June 1988 until December 1988, Air Ontario conducted F-28 operations without having an F-28 MEL approved by Transport Canada. Operation of an aircraft without an approved MEL is permitted; however, the Air Ontario F-28 aircraft could not have been legally operated between June and December 1988 with any essential aircraft equipment inoperative. Evidence before me revealed that Air Ontario operated the F-28 aircraft between June and December 1988 with essential aircraft equipment inoperative.

Maintenance History

Airframe

The aircraft C-FONF, serial number 11060, had a date of manufacture of November 3, 1972. The aircraft was initially sold to Turk Hava Yollari (THY) (Turkish Airlines, Istanbul) about January 1973. It was subsequently sold by THY to Transport Aérien Transrégional (TAT) (France) about January 1988, and then leased by TAT to Air Ontario for the period March 15, 1988, to March 14, 1989. The aircraft was accepted by Air Ontario about mid-March 1988. At that time, the aircraft had flown a total of 20,394:38 hours and 23,316 cycles. (A cycle is one takeoff and one landing.) At the time of the crash, the aircraft had flown 21,567:23 hours and 24,635 cycles.

The aircraft's maintenance trail, from the time the aircraft was prepared for delivery to Air Ontario to the time of the crash, was closely examined by Commission investigators and canvassed at length during the hearings of this Inquiry. Prior to delivery to Air Ontario, the aircraft was inspected and brought to normal TAT and Canadian standards. It became known during the testimony of Mr Teoman Ozdener, a former director of maintenance for Air Ontario and previously the engineer responsible for the F-28 at THY, that the aircraft had been parked and stored for about two years at THY, Istanbul, before it was purchased by TAT. Mr Ozdener holds a master of science degree in mechanical engineering from California State University and has been employed as a senior liaison engineer in structures and substructures for McDonnell Douglas. Mr Ozdener testified that during the type of storage to which C-FONF was subjected, parts of the aircraft, especially hydraulic seals, deteriorate and lead to breakdowns that in turn cause delays and flight cancellations.

The records for the maintenance performed since the aircraft entered Canada indicate that the aircraft was maintained in accordance with the

Transport Canada–approved maintenance system contained in the Air Ontario Maintenance Control Manual. The records also indicate that all requirements of the approved maintenance program were completed on time or within the approved tolerance (10 per cent of the time between inspections or other related activity, or 50 hours non-cumulative, whichever is less). As well, none of the components on the aircraft when it crashed was overdue for inspection, replacement, or overhaul on a time basis.

During the review of the maintenance records, it was discovered that the records contained numerous entry and mathematical errors. It was the opinion of Ms Summers that, at the time of the accident, the errors had not resulted in any components going beyond their operating limits or any inspections being missed. (It was discovered during the investigation of the wreckage that the left and right inboard wheel brakes were worn beyond specified limits, but errors in the records were not a factor here.)

The aircraft was last reweighed on May 16, 1988, at TAT, France, and had a basic empty weight of 36,501.89 pounds and a centre of gravity of 483.22 inches aft of the datum. The weight and balance were amended October 19, 1988, to 36,539.00 pounds and 483.06 inches, because of some minor additions, deletions, and substitutions (primarily the change to a different flight data recorder). Although an additional weight of approximately 136 pounds was added when new fire-blocking seat material was installed in December 1988, the weight and balance were not appropriately amended. The engineering and inspection manual referred to in the Air Regulations requires that the operator amend and submit revised weight and balance reports to Transport Canada. Although the total weight change may have been small, it still must be included in the weight and balance calculation. By failing to recalculate and revise the weight and balance on C-FONF and submit it to Transport Canada, Air Ontario failed to comply with the requirements of Transport Canada's engineering and inspection manual and was therefore in breach of the Air Regulations.

Engines

The history of the engines is outlined below:

	Left (No. 1)	**Right (No. 2)**
Make	Rolls-Royce	Rolls-Royce
Model	Spey RB 183-2 Mk555-15	Spey RB 183-2 Mk555-15
Specification	1037	1037
Serial number	9130	9187
Date of manufacture	December 1971	February 1973
Date installed C-FONF	April 28, 1988	May 4, 1988

At the time these engines were installed in C-FONF, this aircraft had a total time of 20,393:03 hours and 23,315 cycles. The engine times/cycles at the time of installation were as follows:

	Left (No. 1)	Right (No. 2)
Total hours since new	21,729:55	10,026
Hours since overhaul	8,380:10	4,037
Total cycles since new	20,938	6,641
Cycles since overhaul	9,055	2,357
Cycles since hot section inspection (HSI)	zero	zero

Prior to its first flight of March 10, 1989, C-FONF had a total time of 21,565.7 hours and a total of 24,632 cycles. According to the Air Ontario SOC log, the aircraft flew 1:41 hours and three cycles on March 10, 1989. The engine times/cycles at the time of the crash were calculated to be as follows:

	Left (No. 1)	Right (No. 2)
Total hours since new	21,901:57	10,198:02
Total cycles since new	21,258	6,961

As of March 10, 1989, all applicable engine airworthiness directives (ADs) had been complied with. Logbook entries verify that both engines were maintained in accordance with the approved maintenance program.

Deferred Unserviceabilities

An exhaustive review of the journey log for C-FONF, undertaken during the course of the hearings of this Inquiry, revealed that many aircraft unserviceabilities were carried forward or deferred by the Air Ontario maintenance department in the approximately six months that Air Ontario operated its F-28s without an approved MEL. The following is a list of such deferrals dating from June 9, 1988, when Air Ontario first began revenue operations with the aircraft, to December 19, 1988, when the F-28 MEL was approved by Transport Canada and officially put into use by Air Ontario. The evidence was that Transport Canada had given verbal approval to the proposed MEL, but there was disagreement over the actual date that verbal interim approval of the MEL by Transport Canada was received by Air Ontario. This subject is covered fully in chapter 16 of this Report, F-28 Program: APU, MEL, and Dilemma Facing the Crew.

[1] June 9, 1988 – Fuel reported venting from wing vents by YZ ATC [Toronto Air Traffic Control]. Rectification – deferred MX Control #0158 YAM 9-6-8.

[2] June 19, 1988 – #2 system auxiliary AC hydraulic pump intermittent. Rectification – carried fwd.

[3] June 22, 1988 – F/O clock u/s. Rectification – carried fwd.

[4] June 23, 1988 -- left flight control light (hyd pump) illuminated constantly. Rectification – carried fwd.

[5] June 24, 1988 – Flight crew reported #1 hyd quantity system gauge u/s. Rectification – operate as per Flight Manual operating deficiencies list Vol 1. Deferred.

[6] June 28, 1988 – Anti-skid u/s. Left side does not test in flight. Rectification – carried forward. Operate as per Flight Manual.

[7] July 15, 1988 – Captain's clock u/s. Rectification – Swapped for F/O clock. F/O clock u/s and carried fwd.

[8] July 27, 1988 – Cockpit pack temperature control only in manual position. Rectification – carried forward.

[9] August 15, 1988 – Flt crew reports APU fire ext test to be intermittent. Rectification – carried forward. Operate as per Flight Manual CDL [Configuration Deviation List].

[10] August 31, 1988 – Yaw damper slightly unsteady. Rectification – C/F.

[11] September 1, 1988 – Aileron control pilot wheel slight left right motion in cruise; autopilot on causing yaw damper to move all the time. Rectification – previously carried forward ... Servicing tool on order.

[12] September 12, 1988 – Yaw damper is starting to slew tail around again resulting in aileron's moving with slight rocking motion. Rectification – carried forward. Operate as per F-28 Flight Handbook.

[13] September 22, 1988 – F/O's alt [altimeter] not lit. Rectification – C/F. Parts on order.

[14] September 22, 1988 – Capts panel does not have lit time piece. Rectification – C/F

[15] September 25, 1988 – Barber pole showing at least once during take-off and landing roll. Indications problem only, liftdumpers do not come out. Rectification – carried forward. Test equipment ordered.

[16] September 25, 1988 – #2 fuel flow meter is intermittent. Works about 75% of the time. Did same in #1 position yesterday. Rectification – carried forward. Parts ordered.

[17] October 9, 1988 – Please adjust F/O's rudder pedals for correct left right alignment. Rectification – carried fwd.

[18] October 14, 1988 – Cockpit a/c pack magnetic indicator shows "off line" most of the time. Temperature can only be controlled manually. Rectification – carried forward – continue operation in manual mode.

[19] October 19, 1988 – APU hangs up at 20% RPM, TGT then rises to red line (705°) without further increase in RPM. APU was turned off. Rectification – APU u/s – Deferred.

[20] October 29, 1988 – Wing and tail anti-ice panel goes dark (lights go out) when selected on, comes back on when selected off. Rectification – carried foward.

[21] November 15, 1988 – If cockpit air conditioning not selected cold after t/o the pack drives full hot producing a hot smell. Rectification – previously carried fwd.

[22] November 23, 1988 – Knob on L/H thrust index gauge slips. Rectification – C/F. Part on order.

[23] November 28, 1988 – Gen. #1 drive coupling disengaged. Rectification – C/F.

[24] November 30, 1988 – Cockpit pact temp control u/s in auto selection. Rectification – C/F.

[25] December 2, 1988 – Upper half of airfoil anti-ice panel is without lights (intermittent, when pressure is applied lights come on). Rectification – Deferred.

[26] December 2, 1988 – Automatic control for cockpit air cond pack is intermittent. Magnetic indicator is "off line" most of the time, occasionally it goes to "in line." Rectification – previously deferred.

[27] December 14, 1988 – Autopilot rolls wings inducing yaw in put above 15,000′ and mach .60 same as page 18866 #1. Rectification – C/F.

[28] December 18, 1988 – #3 Alt under frequency when APU loaded up. Rectification – C/F as per ANO Series 2, #20. Alt not ESS [essential?] for flight.

As will be seen in chapter 16 of this Report, which deals in detail with the MEL, the definition of "essential equipment" in ANO Series VII, No. 2, is ambiguous. In the absence of a clear definition as to what constitutes essential equipment, it may be that some of the above-noted defects do not relate to essential aircraft equipment; it is, however, obvious that some of them do relate to it. Some of the more obvious defects related to essential equipment are those listed above as numbers 2, 4, 9, 15, 19, 23, and 25, but the list is not necessarily complete. *Any deferral of a defect related to a piece of essential equipment must be made with reference to an approved MEL.* This procedure must be carried out to ensure that the deferral is made with a full appreciation of the ramifications of the unserviceability on both operations and maintenance; it is also required by legislation. Based on the evidence before me, it is my opinion, and I conclude that, *any deferral of a defect related to an item of essential aircraft equipment, without reference to an approved MEL, effectively voids the certificate of airworthiness.* That being the case, it follows, and I find, that Air Ontario operated its F-28 aircraft, C-FONF, on a number of occasions without a valid certificate of airworthiness.

Reportable Incidents

The Canadian Aviation Safety Board Regulations, as part of the *CASB Act*, define, in section 2, what are "reportable incidents" and require, pursuant to section 5(1), that these incidents be reported to CASB. Contravention of the Act or the regulations is referred to in section 32 of the *CASB Act*, which states, "Every person who contravenes any provision of this Act or the regulations for which no other punishment is provided is guilty of an offence punishable on summary conviction."

One type of reportable incident is smoke occurring in an aircraft. The review of Air Ontario records revealed three apparently reportable incidents related to smoke in the cabin of C-FONF in flight. There is no indication that the incidents were reported to CASB. The three incidents were recorded in Air Ontario logbooks as follows:

> [1] January 21, 1989 – cockpit a/c pack causing smoke in cabin. Pack switched "off" for remainder of flight. Rectification – Carried fwd.
>
> [2] February 27, 1989 – On 1st & 2nd flight of day, cabin filled with oil smoke – <u>very</u> thick. Rectification – found cooling turbine drain releasing oil on duct. Drain repositioned.
>
> [3] March 6, 1989 – On first t.o. cabin became smoky. Pass. complained. Smoke detector went off. Cabin temp. on overhead showed 30°. Smoke went away after 5 – 10 mins. Rectification – oil found in APU outlet ducts, oil removed.

On March 8, 1989, aircraft C-FONF, piloted by Captain Robert Nyman, at the time an Air Ontario F-28 check pilot with no management duties, and First Officer Keith Mills took off from Winnipeg. Just after takeoff, the cabin once again filled with an oily haze, which, according to Captain Nyman, emanated from the APU. Captain Nyman stated in evidence that this occurrence was another instance of a recurring problem on the aircraft. It had not been logged in the aircraft journey logbook, but Captain Nyman agreed that it should have been entered. No record of deferral appears in the logbook, nor is there a description of rectification by maintenance. Neither this occurrence nor the three previously listed ones were reported to CASB, nor was the aircraft grounded until such time as the problem could be rectified.

The absence of any report to CASB with respect to the above occurrences indicates either a lack of awareness of the reporting requirements by those involved, who are presumed to know the law, or a reluctance to report the incidents owing to the possible consequences and the follow-up actions required. In the worst-case scenario, these incidents could have entailed the grounding of the aircraft until a thorough CASB investigation had been completed, which could have

resulted in loss of the aircraft from revenue service for a considerable period. The temptation not to report to CASB was obviously there. In my view, it is unlikely that flight crew and maintenance personnel would be ignorant of the requirement to report cabin smoke to CASB. The evidence is overwhelming that Air Ontario management and many of the F-28 flight crews were bent on keeping the F-28s flying.

State of Serviceability of C-FONF on March 10, 1989

The following unserviceabilities were outstanding according to the C-FONF journey logbook on the morning of March 10, 1989, prior to departure from Winnipeg:

[1] September 22, 1988 – Capt's panel does not have lit time piece. Deferred IAW ANO Series 2-20. Licence ACA 87077. (Note – This deferral had been carried for almost six months).
[2] February 8, 1989 – Roll and yaw not working properly in autopilot. Licence ACA 87118. Deferred
[3] February 8, 1989 – F/O windshield wiper creeps up in flight. Licence ACA 87118.
[4] February 23, 1989 – Pilot reports LH fuel gauge still intermittent (reads full). Licence ACA 87015. Carried Forward – Deferred.
[5] February 24, 1989 – Number 1 Constant Speed Drive warning light tests but won't come on after shut-down. Licence ACA 87042. Deferred MEL 02-24.
[6] March 9, 1989 – APU will not fire test. Licence ACA 87101. Deferred MEL 49-04.

During her testimony before me, flight attendant Sonia Hartwick stated that there were other discrepancies brought to the attention of the flight crew, either by Mrs Hartwick herself or by flight attendant Katherine Say, prior to the first flight on March 10, 1989. As far as could be determined during the investigation, these discrepancies were not entered in the journey logbook or any other log. It is not known what determination the flight crew may have made about these reported discrepancies, but there was no evidence that the discrepancies were rectified at any time. They were as follows:

1 The exit light over the main entry door was not working.
2 The exit light over the cabin door, on the cabin side, was not working.
3 The cabin emergency floor lighting was dimmer than normal and had a bluish rather than a bright white colour.
4 There were three altitude-compensating oxygen masks missing from the back of the aircraft.

5 There had been some difficulty closing the main entry door in Winnipeg. A plastic surclip that normally held the door handle in the stowed position when the door was closed had broken, and the handle was being held in place by double-sided tape. The difficulty in closing the door could have been attributable to the fact that the door operating handle was being held in the stowed position by the tape while an attempt was made to close the door. Neither the tape itself nor the fact that the surclip was broken apparently posed any danger of the door opening inadvertently.

I have no reason to believe the flight crew was not made aware of the above discrepancies. Since the approved MEL did not provide alleviation for some of these deficiencies and since the crew took off without having these discrepancies rectified, the crew would have done so in violation of existing regulations regarding essential equipment unserviceabilities.

Validity of Certificate of Airworthiness of C-FONF while Operated by Air Ontario

Letter of Approval

My review of the evidence suggests that a letter of approval is an administrative tool, with no basis in law, used to assist the regulator in ensuring that operators have knowledge of their requirements with regard to the certificate of airworthiness and to assist the regulator in auditing and inspecting the company to which the letter applies. Upon reviewing the evidence regarding Air Ontario's letter of approval, it is my opinion that the absence of any reference to the F-28 aircraft in the letter did not affect the validity of C-FONF's certificate of airworthiness.

Maintenance Control Manual

Amendment number 3, which added the F-28 aircraft to the Air Ontario Maintenance Control Manual, was approved June 3, 1988. This amendment effectively gave Air Ontario the right to operate C-FONF as long as the carrier followed the maintenance practices described in the approved manual, other regulations not considered. Upon review of the evidence and information before me, it appears that Air Ontario deviated from its Maintenance Control Manual only with regard to the minimum equipment list (MEL), as described earlier.

Minimum Equipment List

In accordance with the applicable legislation, and according to the testimony of Transport Canada inspectors Randy Pitcher and Ole Nielsen, the certificate of airworthiness of an aircraft is invalid if the aircraft is operated with any essential equipment unserviceable and there

is not an approved MEL pursuant to which the unserviceability can be deferred. The MEL for the F-28 aircraft operated by Air Ontario was not approved until December 19, 1988. Between the time C-FONF went into operation with Air Ontario in June 1988 and December 19, 1988, the aircraft was frequently dispatched and operated with essential aircraft equipment inoperative. Rectification of this inoperative equipment was deferred without reference to an approved MEL. Rectification was deferred with reference to the flight manual's operating deficiencies list, deferred with reference to the configuration deviation list, or deferred by stating "operate as per the F-28 flight handbook"; or the deficiency was simply carried forward. As well, there is ample testimony that notes describing unserviceabilities were written on pieces of paper and passed from pilot to pilot without the pilots entering the information in the journey logbook until the end of the flying day; effectively, this practice allowed the aircraft to be flown when unserviceable. None of these procedures is Transport Canada approved. Based on the evidence before me, and as previously stated, Air Ontario, prior to December 19, 1988, when the F-28 MEL was finally approved, operated C-FONF without a valid certificate of airworthiness each time it operated the aircraft with essential equipment inoperative.

Findings

Aircraft Wreckage Investigation

- There were no pre-crash faults found with the aircraft or engines that could have contributed to the accident.

- The engines were operating at takeoff power or greater during the takeoff.

- The engine anti-icing system was selected ON during the takeoff.

- All aircraft and engine damage was the consequence of impact with trees and the ground and the ingestion of foreign material.

- The fact that one of the engines reportedly smoked during a start at Winnipeg was not related to the accident.

- The auxiliary power unit (APU) was unserviceable because it would not fire test, and it was not used during the stop at Dryden.

- During post-crash testing of the APU, it was discovered that its fuel

control unit was unserviceable.

- The landing gear was moving to the up position at the time of the crash.

- The wing flaps were positioned at 18° at takeoff but were found at 25 to 27° extended at the time of the crash.

- The wing and tail anti-icing system was off during the takeoff.

- There was no evidence of fire prior to the aircraft striking the trees.

- The flight recorders revealed no useful information because they were destroyed in the post-crash fire.

- The brakes of both inboard main wheels were worn beyond limits.

Airworthiness of C-FONF

- Both aircraft main engines were maintained in accordance with the approved maintenance program.

- Air Ontario personnel often deferred aircraft unserviceabilities in an unauthorized manner and then flew the aircraft without the unservi-ceability being rectified.

- Because of the unauthorized manner in which some aircraft unservice-abilities were deferred, Air Ontario on a number of occasions operated its F-28 aircraft, C-FONF, without a valid certificate of airworthiness.

- Air Ontario failed to report certain reportable aircraft incidents to CASB in accordance with requirements of the *CASB Act*, as evidenced by the fact that on at least four occasions there was smoke in the cabin of an Air Ontario F-28, yet CASB has no record of such reports to that effect.

RECOMMENDATIONS

Aircraft Crash Charts

Based on the evidence that there were no F-28 aircraft crash charts

available at the crash, fire-fighting, and rescue (CFR) unit at Dryden on the day of the accident, and that the flight data and cockpit voice recorders were destroyed by fire, I had intended to make recommendations as to the availability of crash charts and their use in the training of CFR unit personnel. It appears, however, that, since the hearings of this Commission, Transport Canada has been instrumental in ensuring that all Transport Canada–owned and operated airports have aircraft crash charts readily available. These initiatives more than satisfy my concerns in relation to Transport Canada–owned and operated airports, and recommendations for such airports are, accordingly, not required. In relation to all airports in Canada that are not Transport Canada–owned or operated, I make the following recommendation:

MCR 33 That Transport Canada, in cooperation with airport operators, ensure that all Canadian airports not owned or operated by Transport Canada, which service a scheduled air carrier operation, have appropriate crash charts made available to the same degree and extent as at airports owned and operated by Transport Canada.

Survivability of Flight Data Recorders and Cockpit Voice Recorders in Aircraft Crashes

The recorders in C-FONF were destroyed by fire and were of no use to the investigators of this crash. Because recorders capture essential parameters of aircraft information and performance, and are normally the source of the best investigative information, it is vitally important that their crash survivability be enhanced. I therefore make the following recommendations:

MCR 34 That Transport Canada and the Transportation Safety Board of Canada, through national and international initiatives and committees, continue to press for the adoption of more rigorous survivability test requirements for aircraft flight data–recording systems.

MCR 35 That Transport Canada and the Transportation Safety Board of Canada undertake a research program leading to the development of the most suitable deployable or non-deployable aircraft flight data–recording systems that can reasonably be expected to survive any crash and yield usable data.

MCR 36 That Transport Canada and the Transportation Safety Board of Canada study, or cause to be studied, the location of aircraft flight data-recording systems in aircraft, with a view to assuring the survival of the recording systems in any crash.

Letter of Approval Requirement

It is not clear in the Transport Canada instructions whether the issuance of a letter approval is a requirement. In the approval process of the maintenance control manual or any amendment thereto, in my view, the letter serves a purpose, and thus I make the following recommendation:

MCR 37 That Transport Canada make mandatory the issuance of a letter of approval to an air carrier as an integral part of the approval process of the "maintenance control manual" or any amendment thereto.

Definition of "Essential Equipment"

Testimony given at this Commission's hearings revealed that there is not a definition of the term "essential equipment" that is readily usable or useful to pilots and technicians during normal aircraft operations. It is therefore recommended:

MCR 38 That Transport Canada redefine in Air Navigation Order Series II, No. 20, the term "essential equipment," in order that it be unambiguous and easily understood by pilots and technicians who have to use or refer to the term.

11 AIRCRAFT CRASH SURVIVABILITY

On March 10, 1989, Air Ontario flight 1363 carried 65 passengers and an aircraft crew of four when it crashed. Forty-four passengers and one crew member survived the crash of C-FONF.

The first section of this chapter briefly outlines the survivors' accounts of this crash and their escape from the aircraft wreckage. Most survivors were interviewed and were asked, for purposes of the investigation, to provide their recollections of the crash. Having heard the evidence of many of the survivors and rescuers, I was struck by the fact that so many passengers survived this severe crash and managed to escape from the aircraft wreckage and fire. Their stories are a lasting reminder of the effect that such a tragedy can produce.

Subsequent sections provide more clinical descriptions as to what happened to the aircraft as it crashed.

Passengers' Recollections

> The aircraft was hitting trees, hitting trees, and at that point the aircraft I guess was decelerating and we were inside the blender effect ... you take a blender, threw in some metal, some trees, people and turn it on.
>
> (Transcript, vol. 14, pp. 91–92)

These are the words used by Mr David Berezuk, a surviving passenger and an Air Ontario Dash-8 captain, to describe his memory of that short flight. They vividly depict the reality of the aircraft accident. I heard many other descriptions of the crash, and, for most of the surviving passengers, those few seconds of flight can be described as a slow motion replay in their minds. It seems that, as the realization grew that an accident was inevitable, events crystallized in the memory of each person.

Many of the passengers described how the aircraft taxied out and lined up for its takeoff roll. Many described two liftoffs during the takeoff roll, and some were very specific about the height and angle of the aircraft during each of those liftoffs. As the aircraft finally lifted off near the west end of the runway, many on board knew that something was wrong. Passenger Murray Haines, an Air Canada DC-9 captain, described the takeoff in the following words:

> As the aircraft got to speed, it rotated I would say at least 10 degrees, and it lifted a bit and then sat back down. And then more power was added, and it rotated further. And then the mushing I'm talking about ... it just maintained this attitude and was mushing through the air. It didn't drop a wing until we started hitting the trees.
>
> (Transcript, vol. 19, p. 45)

As the aircraft began hitting the trees, flight attendant Sonia Hartwick shouted to the passengers to brace themselves, telling them to grab their ankles and keep their heads down. In the rear of the aircraft cabin, Captain Berezuk shouted similar commands, as did Mr Clyde Ditmars at the front.

After the first tree strike, the aircraft levelled briefly and a few passengers thought the aircraft would fly away. Then the aircraft hit more trees, and the drumming noise on the bottom of the fuselage intensified. Special Constable Dennis Swift of the Royal Canadian Mounted Police recalled his feelings as the aircraft plunged into the trees:

> I was bent over and hanging on and it was – the trees kept coming and coming and coming. I could – was visually thinking of what was going on.
>
> As the aircraft was going through the trees, I could hear the trees grinding away or tearing away at the underside of the aircraft. It seemed to take forever. It was – it seemed to take an awfully long time.
>
> And I was just, I don't know, subconsciously thinking of how long it was going to be before the trees finally came through the floorboards of the aircraft and what would happen at that point.
>
> It just seemed to take a long time. The rumbling through the trees and the tearing away of metal.
>
> (Transcript, vol. 18, pp. 84–85)

One can imagine the horror experienced by the passengers as the aircraft tore through the trees. Bent in the brace position, some passengers saw a bright flash of light outside the left side of the aircraft, and others saw the light flash through the cabin. Originating from somewhere at the left rear of the aircraft, this flash, described by some as a fireball, shot from the rear to the front of the cabin. The flash was followed by a spray of jet fuel through the cabin that soaked the clothing of many passengers. Then the aircraft came to a sudden stop. Mr Brian Perozak related the abruptness to a previous experience:

> Yes, I remember impacting the trees and it felt like we were almost stopped, and then – and then the impact was worse, like, we stopped dead.
>
> ...
>
> I had an accident a few years ago in a vehicle hitting a tree and the truck stopped dead at 40 miles an hour and, like that, even harder, without moving.
>
> (Transcript, vol. 16, p. 241)

From the testimony, it was apparent that the abrupt stop rendered many surviving passengers momentarily stunned or unconscious. Those who remained conscious testified that, as the fuselage came to a stop, the overhead bins became dislodged, causing cabin baggage stored therein to move about and to fall on the passengers below. Snow, mud, and parts of trees had entered the cabin, covering some of the passengers. More fuel sprayed on the still seat-belted passengers through holes in the cabin. As they fumbled for their seat belts, they smelled smoke, saw fire, and searched in a darkened cabin for a way out.

The aircraft had broken into three parts and lay in the woods in the shape of a large U. The front portion of the aircraft, compressed to the left, formed one arm of the U; the main fuselage, the passenger cabin portion of the aircraft, formed the base; and the tail section lay parallel to the nose of the aircraft.

There were 13 rows of seats in the aircraft, each row with three seats to the left of the centre aisle and two to the right (figure 5-2 in chapter 5, Events and Circumstances Preceding Takeoff). When the tail section swung away from the fuselage, the last row of seats, row 13, remained with it. Captain Murray Haines and one of his daughters found themselves almost in the open on the right side of this section. Two RCMP special constables and a prisoner were more enclosed on the left. With the exception of Special Constable Dennis Swift, all these persons easily exited the aircraft. He suffered a severely fractured leg, and, after removing his seat belt, he fell into the gap between the fuselage and the tail section. He was then stepped on while he lay there, until fellow passengers Mr Alfred Bertram and Mr John Biro dragged him to a safer position.

Passengers from row 8 back to the rear of the aircraft found that escape out the front of the aircraft was blocked by what seemed to be an impenetrable wall of debris. The left wing of the aircraft had disintegrated during the aircraft's descent through the trees, and a curtain of fire blocked escape to the left. Mr Thomas Harris, seated beside the left-side emergency exit at row 8, was the only survivor to escape through that exit, suffering severe burns to his hands in doing so. Passengers seated in the rear of the cabin went through either the opening in the fuselage at the rear of the aircraft or through the right-hand window

exit. This exit may have been partly blocked, either inside or outside the fuselage, and those who exited this way could not determine if their point of egress was in fact the emergency exit.

Seated at the rear of the aircraft were a number of families who were travelling on spring school-break vacations. The Godin family of four from Thunder Bay was seated in row 9. Mr Daniel Godin was travelling with his wife and two children. After assisting his wife and one child exit the burning wreckage (his other child followed another passenger out of the aircraft), he returned to the interior of the rear portion of the aircraft, where he helped two survivors extricate themselves from debris and moved them towards the opening in the rear of the fuselage. He left the wreckage only after assuring himself that there were no other passengers amid the debris in the tail section visible through the thick, black, acrid smoke. After ensuring the safety of his family outside the aircraft, Mr Godin proceeded to the burning front section of the aircraft, which he entered. He then assisted four injured survivors to a safe distance from the burning aircraft. Next he opened suitcases that had been strewn about and distributed clothing to some survivors as protection against the snow and the cold. Despite having been doused with fuel during the crash sequence, he returned to the aircraft and attempted to rescue two passengers from an intense fire in the left-hand portion of the interior aircraft, only to be forced back by the flames and heat. It has been estimated that, in addition to his family, Mr Godin assisted 12 passengers to escape the aircraft.

Captain Haines, having first taken one of his daughters away from the aircraft, returned to extricate his wife. His other daughter exited through what may have been the right emergency exit location.

At the front of the wrecked aircraft, surviving passengers faced even greater dangers. Here the fire moved the fastest, and here the cabin area was compressed by the crash forces. It was from row 7 forward, and principally on the left side of the aircraft, that the majority of the fatalities occurred.

Two friends, Mr Brian Adams and Mr Brian Perozak, on their way to a curling tournament, were seated in the two seats on the right side of the aircraft in row 4. After the crash, they found themselves buried under trees, snow, luggage, and part of the aircraft. They could feel other passengers exiting over the part of the aircraft wreckage that was covering them. After a few minutes of struggle to free himself from the debris, Mr Perozak was able to unlatch his seat belt. He then crawled through a small opening in the rubble and got clear of the aircraft. Turning around, he observed his friend Mr Adams, whose legs were trapped under the wreckage. Mr Perozak immediately began to remove debris from his friend's legs. During this time, others exiting the aircraft fell over both of them as they hurried to leave the aircraft wreckage. Mrs

Nancy Ayer, her body in flames, fell on the trapped Mr Adams; she was then assisted by Mr Godin to an area away from the burning aircraft. Despite having suffered what would prove to be fatal burns, she encouraged rescuers to look after others. Mrs Shelley Podiluk, holding her baby, exited the wreckage with the assistance of Mr Ricardo Campbell. During this time, the fire in the aircraft was quickly approaching Mr Perozak and the trapped Mr Adams. The fire was close enough for Mr Perozak to feel the synthetic fibres in his sports coat become tacky from the heat. Mr Adams, trapped and lying on his back, saw a nearby tree catch fire and realized that there was little time left to escape. He described the scene as follows:

> And the heat was – the heat was getting hot and Brian [Perozak] was saying the heat is getting unbearable, I can't stand the heat or something like that.
>
> ...
>
> And I can remember thinking that we have time to give it one more try to pull my leg free. If we can't, I have got to tell him to get out and I'm on my own.
>
> And Brian at this time wedged his hands so he was grabbing on my calf and I somehow got some leverage on my – with my right foot on something and we just tug and all of a sudden it just popped out for some reason.
>
> (Transcript, vol. 16, pp. 203–204)

Many of the passengers who exited the right side of the aircraft gathered in the woods; flight attendant Sonia Hartwick and others called for everyone to stay together away from the aircraft. On the left side of the aircraft, two passengers were later found pinned in the wreckage and were extricated by rescuers; Mr Michael Kliewer, suffering burns and massive trauma, lay pinned on top of Mr Uwe Teubert, his body sheltering Mr Teubert from the heat of the fire. Mr Teubert shouted for help, but, although some may have heard his calls, it appears that no one discerned where they were coming from. It was not until nearly an hour after the crash that these two men were freed from the burning wreckage. When Mr Kliewer was removed, Mr Teubert, badly injured, managed with assistance to extricate himself from the wreckage. Mr Kliewer died later in hospital.

Most of the survivors made their way out of the woods along the path made by the first rescuers on the scene. The first group of survivors reached Middle Marker Road less than 20 minutes after the crash. At 12:32 p.m., 21 minutes after the crash, Fire Chief Ernest Parry radioed that there were about 20 to 25 survivors walking to the corner of McArthur and Middle Marker roads. Many of these people, suffering from burns and other injuries, departed the crash site in their shirt-

sleeves and stocking feet. They were put into vehicles or sent to a nearby house to keep warm. All were subsequently transported to the Dryden hospital, by ambulance and in vehicles volunteered by local people who had come to help.

Another example of unselfish assistance provided to surviving passengers by a crash survivor is to be seen in the actions of Mr Alfred Bertram. A flight services specialist working at Rankin Inlet, Northwest Territories, Mr Bertram was wearing a green Transport Canada security pass. His pass was still clipped to his shirt when he helped carry the stretcher bearing Mrs Ayer from the crash site to McArthur Road. By the time he reached the road, he was wet from falling in the snow, and his hand was frozen in position on the stretcher. When the stretcher was finally placed in an ambulance, almost an hour after the crash, the ambulance attendant, seeing Mr Bertram's badge and assuming he was an airport official, told him to return to the crash site. Mr Bertram headed back down the road, stopped, and helped load equipment to be taken into the site. Then, as he walked towards the crash site, he met two more survivors who were being brought out and was asked by those assisting the survivors to find an ambulance. After doing so and helping at the corner for a few minutes more, he started back down the road again. This time he did not get as far. With "rubbery legs," he decided that he might be a hindrance if he went back to the crash site. One and a half hours after the crash, Mr Bertram was taken to a police car for a much-needed rest.

Dennis Swift, the RCMP special constable, after being assisted from the aircraft and having a crude splint placed on his broken leg by fellow passengers Bertram and Biro, sat in the snow and recorded in a notebook his observations regarding the crash. He and one other survivor, Mr Michael Ferguson, were finally taken out of the woods by stretcher more than one hour after the crash. They were the last survivors to leave the crash site. Their ambulance did not depart until after 1:45 p.m., approximately the same time as the ambulance carrying Mr Kliewer and Mr Teubert left. Mr Godin, who travelled to the hospital with Special Constable Swift and Mr Ferguson, helped administer oxygen during the trip and assisted them into the hospital on arrival. Mr Godin's day as a survivor/rescuer finally ended two hours after the crash, when, cold and exhausted, he was reunited with his family at the hospital.

A number of other passenger survivors performed acts of heroism on that day. The evidence of many of the surviving passengers forms part of the record of this Commission. That record, gathered on behalf of all the passengers on flight 1363, has been invaluable.

Survival Factors

The following section consists of observations regarding relevant aircraft passenger survival factors. It is based on the investigation conducted by the human factors investigators, as reported by them in writing and in testimony before this Inquiry.

Cabin Safety

Prior to the final takeoff of C-FONF on March 10, 1989, a pre-flight safety demonstration was conducted by the flight attendants. All passengers had access to emergency information cards for the F-28 aircraft, which were stowed in the seat pouches. The majority of the survivors report having paid some degree of attention to the flight attendants' pre-flight safety demonstration and/or having read the emergency card. Various survivors reported that the overhead luggage racks contained such carry-on items as passengers' overcoats and at least one garment bag, all seat backs were upright, the seat trays were stowed, and all passenger seat belts were properly fastened.

During the week of March 6–10, 1989, flight attendants Katherine Say and Sonia Hartwick detected a number of problems with the aircraft. Each of the problems was recorded in the aircraft journey log and compared against previous entries to determine if these faults had been previously entered and if they had been previously repaired. Sonia Hartwick indicated that Katherine Say had a list of problems which she intended to take up with the manager of in-flight services when the flight attendant returned to the London offices on March 13.

Specifically, smoke, the cause of which was never conclusively determined, had entered the cabin and flight deck on several occasions during that week; there were discrepancies in the number and types of emergency oxygen masks in the passenger cabin; there was some difficulty experienced in locking the main aircraft entry door, and it was necessary to tape the door-locking handle in place; the emergency floor track-lighting was dim and bluish; and the emergency exit lights over both the aircraft's main entry door and the passenger side of the cabin entry door were not working; and there was difficulty with the aircraft pressurization system. It was reported that each of the problems listed above was brought to the attention of the captain, logged in the journey logbook each time it was discovered, and reported to maintenance. However, during that week none of the problems was corrected.

On May 18, 1988, Transport Canada inspector J. Rutherford had conducted a passenger safety inspection of C-FONF. During this inspection, a number of minor safety deficiencies were observed, among them a lack of directional indicators on the floor proximity lighting. On

June 2, 1988, Transport Canada inspector J. Brederlow conducted another cabin safety inspection of C-FONF and commented on the lack of a restraining web for a rear coat closet and the lack of shoulder harnesses for the flight attendants' seats. In fact, there was no legal requirement that the aircraft have flight attendant seat shoulder harnesses installed.

Because the aircraft was so badly damaged by the impact and the post-crash fire, it was difficult to assess many cabin safety issues. For example, some passengers reported that the collapsed overhead luggage racks and ceiling panels restricted their egress from the aircraft. However, with the cabin being all but destroyed by fire, it was not possible to determine if the collapse was attributable to design, construction, or maintenance. Given the nature of the impact and the breakup of the fuselage, it would seem unreasonable to expect luggage racks and ceiling liners not to collapse. The speed with which the fire took hold of the cabin interior was also considered. There is a requirement that passenger seats be constructed with fire-blocking material, but rapid fire propagation continues to be a recognized problem with most aircraft. (The issue of cabin material is addressed further in a later section of this chapter.)

Another cabin safety issue involves the clothing worn by the flight attendants. Flight attendant Hartwick's outer clothing comprised slip-on shoes, a light dress, and a sleeveless vest. She lost one shoe in the aircraft and the other outside the aircraft, in the snow. She eventually borrowed a pair of shoes from a passenger, enabling her to better help the survivors. I see a need for there to be more attention paid to clothing all flight attendants in a manner that will allow them to better provide the leadership required of them in an emergency.

Passenger Behaviour and Evacuation

Shortly after the aircraft became airborne, many passengers and at least one flight attendant, Sonia Hartwick, realized that the aircraft was not flying properly. Even before the initial contact with the trees, a few passengers were assuming a brace position, and flight attendant Hartwick, seated in the midsection of the aircraft in seat 8D, commanded passengers to brace themselves. Twenty survivors reported heeding her instructions. Some survivors, particularly those seated beside family members, attempted to protect their seat mates by covering them with their arms or bodies. All survivors, including those who had not heard the flight attendants' commands, had assumed some semblance of the brace position prior to the aircraft striking the ground.

The survivors reported hearing the aircraft initially begin hitting the trees. As the aircraft descended lower into the trees, battering sounds were increasingly more severe and the aircraft was shuddering increas-

ingly more violently. The sound of the aircraft striking trees and the sound of tearing metal, up to and including the final ground impact, was accompanied by passengers' screams and yells. A passenger seated in the midsection of the aircraft reported looking up prior to the aircraft striking the ground and observing passengers being rocked about, items falling from the overhead luggage racks, fuel entering the cabin area and dousing the passengers, and a flash of fire. After ground impact and prior to the aircraft shuddering to a complete stop, passengers, still with their heads down in the brace position, observed a large quantity of dirty wet snow entering the cabin. This snow was mixed with mud and sections of trees. A strong smell of fuel also accompanied the influx of this debris. Because of the confusion inside the cabin, these survivors were unable to determine from which direction this debris entered the cabin. In addition, four passengers reported seeing and hearing electrical sparks and seeing and feeling the heat from a flash fire.

The scene inside the three sections was reported by survivors as chaotic, owing in large measure to the deformation of the fuselage. A large number of seats had failed at their floor-attachment points. These seats, along with their occupants, were strewn about, adding to the confusion. The accumulation of bodies, seats, and debris was primarily concentrated in the left front side of the fuselage. Survivors seated in the centre section described an accumulation of debris varying in depth from two to three feet that, in some cases, totally covered and immobilized them. Portions of the overhead racks had also failed during the last stages of the impact sequence, spilling their contents onto passengers and into the aisle. These broken sections of overhead racks, some already in flames and dripping molten, burning plastic, fell on a number of survivors.

Once the aircraft came to rest, the interior of the cabin sections was dimly lit by overcast daylight entering through the windows and through the two large gashes in the aircraft's right side. The interior lighting system was off, and the aircraft's emergency strip lighting either malfunctioned or, because of the debris, was not visible. Passengers' evidence revealed that the only guidance for survivors to exit the aircraft was from the daylight entering the cabin through the windows and various openings.

At the time the aircraft came to a stop there were already a few spot fires in the interior and on the exterior of the cabin. These fires increased in intensity, and the most severe one, just forward of the left wing, propagated rapidly. The fires soon filled the cabin sections with extremely thick black acrid smoke, severely restricting visibility inside the broken cabin enclosure and rendering normal breathing extremely difficult.

Survivors reported being severely jostled during the crash, and all were stunned or in varying degrees of consciousness by the time the aircraft stopped. Evacuation efforts began within seconds and became progressively more frantic as the intensity of the flames and smoke increased and as more and more survivors regained control of their senses. A few survivors recalled hearing the flight attendant ordering passengers to evacuate.

Forty-seven passengers evacuated, or were evacuated from, the aircraft, of whom two later died in hospital. Although the passenger reaction during the evacuation could not be described as panic, the evacuation was certainly disorganized and chaotic. Many passengers reported seeing other survivors scrambling over them or having their seat backs pushed onto them by passengers during the frantic effort to escape. There were many reports that, despite the frantic situation, survivors were helping one another exit the aircraft, and there were no reports of any competitive behaviour. Because of the increasingly intense fire, the smoke, the spilled fuel, and numerous minor detonations, all passengers perceived an immediate threat to life.

As previously stated, the person occupying seat 8E, the seat immediately adjacent to the right emergency exit, stated that when the aircraft eventually came to rest and he was ready to exit, he egressed through this overwing emergency exit and was followed by the flight attendant, who was seated to his left, and then by a young passenger seated immediately behind him in seat 9E. The survivor from seat 8E believed the emergency exit door had already been opened; he is certain he did not open it. Apparently, these two passengers were the only ones to egress via the right-hand overwing emergency exit.

The passenger in seat 7D stated that while he was pinned in his seat, he reached behind to his right side and twisted and pulled a latch. He could not positively identify the latch, but he may in fact have pulled in the emergency exit door. During the investigation, a burned corner remnant of the emergency exit door was found inside the aircraft abeam the emergency exit. It could not be positively determined how the right emergency exit was opened.

The person occupying seat 8A egressed through the overwing emergency exit to his immediate left. He was certain the exit was opened or torn out during the crash. He suffered serious burns while exiting the aircraft and was later flown to Winnipeg. Immediately after his exit an intense fire developed in the vicinity of the left emergency exit, thereby eliminating its use by any other passengers.

All other survivors exited the aircraft through tears in the aircraft fuselage. Fourteen survivors, including a baby held in her mother's arms, evacuated through a gash in the fuselage just forward of the right wing. Twenty-six evacuated through the opening aft of the right wing;

and one severely injured survivor egressed through an opening forward of the left wing.

There were seven surviving children under age 16, all of whom required some assistance to egress. The assistance was provided either by their parents or by the passengers seated next to the children. None suffered serious physical injury. As noted, one child was a baby held in her mother's arms on board the aircraft.

The aircraft had crashed in a heavily treed area which was strewn with deadfall and underbrush. The wet, heavy snow that had been falling prior to takeoff persisted for some time after the crash, adding to the already hip-deep snow at the crash scene. The temperature was at the freezing point.

All the survivors were poorly dressed for exposure to these conditions. The majority had removed their winter coats and jackets on the aircraft in preparation for the flight to Winnipeg. Eleven of the 47 survivors, including the flight attendant, lost their footwear during the crash or while extricating themselves from the aircraft.

As the survivors, most of them injured and many of them suffering from shock, exited the aircraft, they gradually gathered into small groups among the trees some 200 feet from the burning aircraft. Three survivors were too seriously injured to move any more than approximately 75 feet from the aircraft. They were assisted and tended to by less seriously injured survivors.

Once away from the immediate threat posed by the fire, the survivors were more motivated to work collaboratively, and in many cases they performed selfless acts in attempts to reduce the suffering of those less fortunate than themselves. Some passengers removed their jackets to allow others with no shoes to stand on them, and others gave up their shirts or sweaters to those who were cold. Some passengers performed rudimentary first-aid treatment on the injured. Other passengers provided encouragement to those who were more emotionally upset, and still others provided physical assistance to those who had difficulty walking.

The surviving flight attendant, Sonia Hartwick, despite her emotional shock, provided some of the leadership required to keep the groups close together. Once out of the aircraft she commanded those survivors still exiting to continue moving well away from the fire; then, while waiting for evacuation from the site, she ensured that survivors, many of whom were suffering from shock, did not wander off into the woods. She provided encouragement to survivors as well as assisting with the care and comfort of a severely burned passenger.

Seat Belts

Survivor statements indicate that all seat belts held; however, several survivors stated that they had some difficulty releasing their seat belt buckles. It is probable that the agitated state of some of the survivors resulted in frantic and inept efforts at releasing their seat belts. Others had difficulty finding their seat belt buckles because, since their bodies had shifted in their seats during the crash, the buckles were not positioned where expected. Some survivors indicated that they had difficulty because their access to the seat belt buckles was restricted by debris.

One survivor who reported having difficulty with his seat belt was Mr Gary Jackson, a prisoner in handcuffs being escorted to a detention centre. Mr Jackson believed his difficulty was due to a combination of factors: he was somewhat in panic or shock, his hands were burned and very painful, and he had handcuffs on. He was unable to release his seat belt until one of the escorting special RCMP constables, Mr Donald Crawshaw, who had initially left Mr Jackson in his seat, returned to the wreckage to assist the prisoner in response to his calls for help.

The fabric portion of most of the seat belts was destroyed by fire. A full physical assessment of the effectiveness of the seat belts was therefore impossible. However, each passenger seat originally had two seat belt anchor points, two anchors, and two parts of a single buckle; thus, there were 130 seat belt anchor points, 130 seat belt anchors, and 65 buckles.

All 130 seat belt anchor points were in place, but only 121 of the seat belt anchors were in place and intact; two further seat belt anchors were recovered intact, but were not in place. Only five seat belt buckles were eventually recovered, four of them still operative. None of the seat belts for the flight attendants' seats or the cockpit seats was recovered.

Assuming all passenger seat belts in the aircraft were the same as those recovered, it can be said that they met Canadian regulatory specifications. Because none of the flight crew seat belt components was recovered, no statement of compliance or non-compliance with Canadian regulatory specifications can be made.

Seats

It was found that many of the passenger seats were detached from the floor and were bunched in the forward portion of the aircraft. Most of the passenger seat frames were damaged and distorted as the result of impact and deceleration forces. The seats in rows 6, 7, and 9 on the right side of the fuselage were still in place after the crash. The seats in rows 13 right and 8 left showed very little frame damage, but they were dislodged and the front attachment knobs were missing.

In general, the seats towards the front and the left side of the aircraft were more severely damaged than were the other seats. The strongest part of the seats is the twin tubular beam that forms the base for each individual row, and many of these beams were bowed from excessive force. The most severe seat beam deformation was observed in rows 1 to 3 on the right side and rows 1 to 7 on the left side. The majority of these seats were subjected to deceleration forces with significant components in the sideward and downward directions during the final phase of the crash (analysed in the Flight Dynamics study, technical appendix 4).

Because of the fire destruction, apart from the very base structure of the captain's seat, nothing remained of the flight attendants' seats or the cockpit seats.

The forward flight attendant's seat was a pedestal seat without armrests, side restraints, or a rigid back. The seat was forward facing, located in the galley area, to the right of the centre line of the aircraft, and had a lap belt but no shoulder harness. Its location was intended to allow the flight attendant immediate access to an exit and the aircraft's only exit chute. Directly in front of this position and facing the seat were the aircraft galley cupboards and equipment. The flight attendant's seat and seat belt met the specifications of Canadian air regulations. For a detailed account of the shoulder harness issue, see chapter 22 of this Report, F-28 Program: Flight Attendant Shoulder Harness.

All the passenger seats had been upholstered with fire-blocking neoprene foam material and complied with Transport Canada regulations in regard to fire.

In order to comply with United States FAR 25.813, the seats immediately in front of and next to the overwing exits are required to have seat backs that will not recline. This requirement is achieved by the removal of the cables operating the reclining mechanism. In the other Air Ontario F-28 aircraft (C-FONG), the cables had been removed and the subject seats would not recline; in the accident aircraft, however, the recline cables were still in place.

In all other respects, all seats on C-FONF met Canadian requirements.

Interior Lighting

There were 16 emergency lights and 16 evacuation lights installed throughout the passenger compartment of C-FONF. There were seven lights of each type in the ceiling, and others in strategic places in the cabin. In general, the emergency and evacuation lights were co-located. The emergency lights receive electrical power from normal aircraft power systems, and the evacuation lights receive power from seven self-contained power supply units located throughout the cabin and

containing rechargeable batteries. There is a three-position emergency light switch on the overhead panel on the flight deck, labelled OFF, TEST, and ARM. Under normal flight conditions, this switch is in the ARM position. With this switch in the ARM position, the evacuation lights, being powered by the self-contained battery units, will illuminate in the event of a total electrical power loss to the aircraft electrical system. In addition, there were four exit-location signs in the cabin containing bulbs from both the emergency and the evacuation light systems.

This accident occurred in daylight, and, therefore, lack of light was itself not a problem during the evacuation phase. There was evidence, however, that dark smoke permeated the cabin shortly after the crash, causing difficulty with visibility for the passengers in the central and forward areas of the cabin. If the crash had occurred in darkness, the conditions in the wreckage would have been much more chaotic and may have resulted in a greater loss of life. Surviving passengers were questioned as to whether they saw lights in the aircraft during the time the aircraft was breaking up and when it came to rest. Most passengers did not notice whether lights were on or off. A few stated that they had seen lights of some kind but could not say whether they were aircraft lights; some thought the light may have been from the fire. Two passengers identified lights that they saw as interior cabin lights.

When one considers the bedlam in the aircraft and the smoke and debris in the cabin that would have obstructed the passengers' vision, it is not surprising that the evacuation lights, if they functioned at all after the crash, were not noted by many. With the fuselage breaking into three distinct pieces, the electrical wiring to the lights would surely have been severed in a number of places. It is probable that some individual evacuation lights flashed or came on when the aircraft's normal power supply systems were interrupted during the final phase of the crash. In conclusion, it could not be established with any degree of certainty whether the evacuation lights worked as designed.

Survivor Survey

The Dryden accident provided an opportunity, albeit a tragic one, to obtain valuable information on the emergency evacuation of a medium-size jet aircraft and on other survivability issues. A study of these subjects could lead to the discovery of safety deficiencies and recommendations for their rectification. With this objective in mind, the human factors and survivability group of the CASB accident investigation team formulated a list of specific questions that interviewers would pose to each survivor.

Interviews began March 11, 1989, the day after the accident. Forty-two

survivors were interviewed, many of whom were questioned while in their hospital beds. They represented various ages, backgrounds, and degrees of flying experience, either as a passenger or a pilot.

The following is a synopsis of the questions posed to the survivors and the responses received.

1 *Prior to takeoff from Dryden, did you pay attention to the flight attendants' safety demonstration?*
Nine survivors (21 per cent) responded that they had not paid specific attention to the flight attendants' demonstration. Two of these nine were pilots, and another three of this group stated that they had paid attention to the demonstrations given prior to takeoff in Thunder Bay.
It is interesting to note that one of the passengers, a 12-year-old girl, indicated that she had neither paid attention to the demonstration nor read the aircraft's evacuation card because "[i]t's always the same stuff and I know it all anyway." This passenger had difficulty releasing her seat belt after the crash and required assistance from the passenger seated next to her. The seat belt release, according to the passenger who provided assistance, functioned normally.

2 *Prior to takeoff from Dryden, did you read the evacuation card?*
Eighteen survivors (43 per cent) replied that they had not read the evacuation card.
Seven survivors (17 per cent) had neither read this card nor paid attention to the flight attendant safety demonstration.

3 *Did you assume the brace position prior to impact?*
Five survivors (12 per cent) stated that they had not. On further questioning, however, it was determined that although these survivors had not assumed the textbook brace position, these passengers had all braced themselves in some fashion. It is particularly significant to learn that 20 (48 per cent) of the survivors replied that they had assumed their brace position as a result of the flight attendants' orders prior to impact.

4 *Did your seat collapse as a result of the accident?*
Thirty-two (76 per cent) replied that their seat did not collapse, and five (12 per cent) stated that their seat collapsed.

5 *Did you have a problem releasing your seat belt?*
Seven respondents (17 per cent) replied that they had difficulty releasing their seat belt. Among these passengers was the prisoner travelling with his wrists handcuffed in front of him. One respondent mentioned undoing his trouser belt instead, as a result of nervousness.
Two survivors (5 per cent) related difficulties as a result of the seat belt buckle, once fastened, being displaced to one side of the abdomen.

6 *Did you strike any object in the aircraft space around you or were you struck by any object?*
Nineteen survivors (45 per cent) indicated either having been struck by an object or hitting something during the crash sequence. Only two respondents positively stated that their head struck the seats in front of them. Seventeen (40 per cent) could not remember what they had hit or what had hit them. Of this group, most stated that their lack of recollection was due to having their head lowered in the brace position and/or having their eyes closed. Many mentioned that there was too much debris moving around the cabin in a blur to identify what was hit.
Nineteen passengers (45 per cent) recall having overhead racks falling on top of them.
7 *Did you have any problems exiting the aircraft?*
Eight respondents (19 per cent) mentioned having some difficulty exiting the aircraft.
Most of the problems resulted from debris in the aircraft. Three survivors (7 per cent) had difficulty because their feet became lodged under the seat in front of them during the crash sequence.
8 *Did you assist anyone to exit the aircraft?*
Fifteen survivors (35 per cent) reported having given some form of assistance to other passengers.
9 *Did you receive assistance to exit the aircraft?*
Eleven passengers (26 per cent) reported having received assistance.

Crash Survival and Impact Survival

"Crash survival" is related to the ability of the aircraft's occupants to survive the impact or impacts, to evacuate the aircraft before conditions become intolerable as a result of fire, submersion, and other hazards, and to survive post-crash conditions until rescued.

"Impact survival" is related to the aircraft's ability to protect the occupant during a crash, with the following criteria applied:

1 The occupants' immediate environment must remain relatively intact; that is, there should be no intrusion into the livable space.
2 The deceleration forces acting on the occupants should not exceed human tolerance.
3 The seat/restraint system should prevent injuries from a second collision.
4 The immediate environment should protect the restrained occupants against serious contact injuries.

This section of the Report deals with the ability of the aircraft and all its parts to protect the occupants from the effects of rapid deceleration and the breaking up of the aircraft and considers the security of the seats and seat belts. The crashworthiness analysis provides a general understanding of the average magnitude of the impact forces experienced during the crash. The susceptibility of the aircraft to fire and the effects of the fire on the occupants are discussed in the following section of this chapter.

Mr James Hutchinson, a mechanical engineer and chief of the Engineering Analysis Division of the Canadian Aviation Safety Board (CASB), who served as chairman of the investigation team's aircraft structures group, outlined in testimony the reason for conducting an investigation into the structural breakup of an aircraft in an accident. Basically, the structures investigation provides an overall assessment of the crash dynamics of the accident sequence to determine the nature of the breakup patterns. These patterns are then compared with what could be normally expected, based on historical data, for the type of crash being investigated. If a particular breakup pattern was not consistent with the assessment of the impact dynamics, then a detailed examination would be required. In this accident, the breakup patterns of the F-28 aircraft, C-FONF, were all consistent with the overall assessment of the impact dynamics, and the investigators did not observe any breakup pattern that, in an engineering-design sense, was considered to be of an unexpected nature or could not be explained to their satisfaction.

Using the topographic maps produced by the survey team, the structures group estimated the terrain angle in the crash area to form a downslope of approximately 4° in the upper section of the wreckage trail, varying to approximately 8° on the lower section. The crash calculations were divided into two parts: the first from the point where the aircraft started striking trees on the top of the knoll, approximately 726 m from the end of the runway until the aircraft struck the ground 144 m farther on; and the second from the point the aircraft struck the ground until it came to a stop. The aircraft slid about 80 m after striking the ground.

Calculations using an estimated aircraft speed of 205 to 220 feet per second (121 to 130 knots) and an estimated coefficient of friction for flight through the trees resulted in longitudinal deceleration levels of approximately 1.33 g for the first part of the crash sequence. The shallow angle of the aircraft path through the trees on a slightly negative slope had the effect of keeping the deceleration levels (g) relatively low. Deceleration levels for the second part were calculated using the impact velocity derived from the previous calculations. It was estimated that the longitudinal deceleration levels on the second part were 2.33 to 3.05 g. The higher levels were attributed to the significant increase in sliding

resistance on the ground over the resistance when travelling through the trees. The estimated deceleration levels are average levels for the aircraft as a whole, based on the total distance travelled. In reality, there were local deceleration levels that varied significantly from the average. The peak vertical level in the forward left side of the cabin, where primary ground contact was made, was calculated to be in the order of 15 to 20 gs. These calculations were based on a structural analysis of the deformation of the seat beam structures of one of the rows of three seats located in the forward left cabin area.

It should be noted that these calculated vertical g forces present only one vector of the peak crash force resultant that governed the damage and injury mechanism during the principal impact. Since the peak horizontal deceleration during main impact is a function of peak vertical deceleration and sliding resistance, the peak horizontal deceleration can be approximated by estimating the coefficient of sliding friction. During his testimony, Mr Hutchinson used a value of 1.4 for this purpose. Applying that value to the calculated vertical gs, the peak horizontal gs at main impact would have been in the order of 21–28 gs.

These estimated peak crash forces affected the front and left side of the fuselage during principal ground impact. They exceeded the human tolerance to deceleration when restrained by a seat belt only, the existing occupant-protection criterion, and the standards for structural integrity of jet transports. The severity of the process explains why the persons closest to the point of impact of the aircraft were killed, disabled or trapped. The survival of a few individuals in this area can be attributed only to random and fortuitous circumstances. The peak horizontal and vertical vectors, which occurred simultaneously, can now be combined to arrive at a crash force resultant in the order of 26–34 gs.

All the seats from the aircraft were recovered. Those from the forward left side in rows 1 to 7 were the most severely deformed, and seats that appeared to be from the right side in rows 1 to 3 were also deformed. Except for seats from rows 6, 7, and 9 on the right side, all seats were detached from their floor anchors. The original positions of some of the seats were determined by matching fracture surfaces and according to relative seat position and damage assessment. All passenger seats, except those from the right side of rows 6, 7, 9, and 13, and all those from row 8, were found to have deformed partially or completely because of impact and deceleration forces.

The regulations adopted by Canada that specify the required strength of passenger and crew seats of transport category aircraft are found in United States Federal Aviation Regulations (FARs) 25.561 and 25.562. The present regulations were in effect as of March 10, 1989. However, FAR 25.561 was amended and FAR 25.562 was added since the F-28 aircraft received its Canadian type certification, and these changes to the

regulations were not made retroactive. In summary, FAR 25.561, regarding inertia forces and applicable to the F-28 seats, required that the structure be designed to give each occupant every reasonable chance of escaping serious injury in a minor crash landing in which the g forces experienced by the occupant do not exceed: upward 2.0 g, forward 9.0 g, sideward 1.5 g, and downward 4.5 g. As well, seat deformation must not occur at or below the noted g loads. Present regulations, namely those covered by the amendment to FAR 25.561, increase the above g minima to upward 3.0 g, forward 9.0 g, sideward 3.0 g on the airframe and 4.0 g on the seats and their attachments, downward 6.0 g, and rearward 1.5 g. FAR 25.562 gives details regarding dynamic testing and inertia forces relating to aircraft seats and their attachments. One of the seat/aircraft design criteria is that the seats must remain attached at all points of attachment, although the structure may have yielded, at a peak floor deceleration of a minimum of 14 g.

As explained above, the forward and left side of the aircraft were subjected to peak crash forces in the order of 26–34 gs; therefore, it is not surprising that many seats were deformed and became detached and that the fuselage broke open in two places.

After the crash, only three seat belts were still anchored to their seats and one additional belt buckle was recovered; all four buckles were found to be functional. Most of the seat belt anchors were still attached to their seat frames. Nine anchors had separated, and only two of these were recovered. Because nearly all of the seat belts were destroyed during the post-crash fire, they could not be properly evaluated for effectiveness.

Upon review of the evidence regarding the structural investigation I can find no fault with or attach any adverse significance to the design and integrity of the F-28 aircraft or to current seat design criteria. It was indeed a stroke of luck for the surviving passengers that the aircraft was broken apart during the final stages of the crash sequence, thus creating an escape route from the wreckage and fire.

Aircraft Fire

Introduction

Most of the information in this section of the Report was gathered and analysed by Mr Brian Boucher, a pilot with Air Canada, a specialist in fire-fighting, and, at present, the director of training for the Niagara-on-the-Lake, Ontario, fire department. He has been an assistant to the Ontario Fire Marshall's Office since 1983 and is involved with the Lester B. Pearson Disaster Contingency Planning Committee. Among the

organizations of which Mr Boucher has been an active member are the Canadian Air Line Pilots Association (CALPA), the International Federation of Air Line Pilots Association (IFALPA), and the International Civil Aviation Organization (ICAO). Among the various fire-related groups on which he has served are the Aircraft Rescue and Firefighting Committee for the National Fire Protection Association, IFALPA's Airport Ground Environment Committee, and ICAO's Aircraft Rescue and Firefighting Study Group. Although his credentials and experience in fighting structural fires are impressive, Mr Boucher noted in evidence that he has never had occasion to participate as a fire-fighter at a major aviation fire.

Mr Boucher is a graduate of the Ontario Fire Academy and, as of April 1990, was in the process of completing a bachelor of science degree from the University of Cincinnati, concentrating on fire and safety engineering. Because of his extensive training and experience, Mr Boucher was asked to participate in the investigation and analysis of the fire aspects of the crash of C-FONF. Since he was not involved in the early stages of the investigation, he gathered the information for his analysis from inspection of the recovered wreckage and from photographs, videotapes, interview transcripts, personal interviews, relevant documents, and evidence adduced at the Commission hearings. He prepared his Fire Analysis Report, which was entered as Exhibit 514 and which, together with his sworn evidence, provided most of the information for the following section.

Fire Propagation

Dynamic Phase

The dynamic phase of the fire represents the time when the aircraft was in motion and on fire. The evidence shows that when the aircraft began to strike the heavy timber, about 726 m from the end of the runway, the left fuel tank ruptured. Fuel from the tank began vaporizing and trailing behind the aircraft in the form of a mist. Mr Boucher was of the opinion that all the fuel from the left tank was released during the time the aircraft was airborne. It is possible the right wing also ruptured and was releasing fuel during the dynamic phase, but there is no confirming evidence. The fuel on the left side of the aircraft ignited, and there is evidence of fire along the aircraft's path through the trees from a point about 50 m after entering the trees to the final resting spot of the aircraft. Trees were scorched but did not continue to burn after the sprayed fuel was burned. There is no evidence that the right side of the aircraft was on fire during the dynamic phase.

The fuel vapour plume created during the dynamic phase of the fire, in its flammable range, was probably ignited from the heat of the left

engine and/or the severed energized electrical components and wiring exposed during the breakup of the left wing. The fuel vapour plume and fire followed the aircraft to its resting position. A number of passengers reported seeing flashes of fire on the left side of the aircraft as it was travelling through the trees.

Investigators who walked the path of the aircraft through the trees reported a strong odour of jet fuel present throughout. The odour was from the raw fuel that was released and not burned and from carbon by-products produced by the fire.

Static Phase

The static phase represents the time commencing after the aircraft was fully stopped and on fire. As the aircraft came to a halt, a large section of the forward left side of the fuselage separated, exposing the passengers seated in this area. The fire plume caught up to the aircraft and became static, initially burning debris and fuel on the left forward side of the aircraft. The fire plume, according to some witnesses, reached as high as 30 feet.

Many passengers stated that there was a strong smell of fuel inside the cabin. The smell was either from the misting fuel that was following the aircraft or from the fuel and fuel vapour that came from the right fuel tank, which was ruptured but not burning at this time. There was evidence of fuel spillage into the cabin, some passengers reporting that they were soaked with fuel. Fuel from the right wing tank poured onto the ground through a blanket of snow. The snow effectively trapped the fuel vapours and prevented a fire from starting on the right side of the aircraft. The vapour plume from the left wing tank probably mixed with a cloud of snow generated during the final impact. Some of the fuel in the vapour plume entered the aircraft, but, because of the snow, it remained out of its flammable range, which was fortunate in that there was an initial fire-free path out the right side of the aircraft for the ambulatory passengers. It is evident that the fuel that splashed on the surviving passengers was not in its flammable range since these passengers did not catch on fire.

The fire plume entered the aircraft through the large opening in the left forward area of the fuselage and contacted the fuselage sideliners, the overhead bins, and the combustible carry-on articles (collectively, the "interior combustibles"). The evidence indicates that burning plastics and other burning articles began dropping almost immediately onto both survivors and non-survivors. Because of the probable heavy concentration of fuel vapour that entered the aircraft and saturated the interior combustibles, the rate of flame-spread was very fast. The left forward area, where the fire entered the aircraft, was where most of the deceased were found. From there the fire then spread forward into the cockpit

and rearward along the cabin ceiling, igniting all interior combustibles. Toxic and flammable gases travelled through convection heating to the ceiling and out through openings in the fuselage. The fire burned from the top down, as evidenced by the fact that the top of the aircraft was burned away while the lower portions of the fuselage remained intact.

The fire was fuel regulated: because of the breaks in the aircraft, there was adequate oxygen to support combustion, and the fire would burn as long as there was material to burn or until the fire was extinguished. It is not likely that fuselage flashover occurred. (Flashover is the spontaneous combustion of heated gases.) In order for flashover to occur, the temperature of the gases in the confined area of a fuselage must exceed 550°C. Although the temperature in this case may have exceeded 550°, the large openings in the fuselage allowed the heated gases to escape, and, accordingly, the fire propagated normally. The vapours from the fuel in the right wing most likely ignited because of the radiant heat and flames from the aircraft cabin as the fire spread. The fire in the area of the right wing was not intense; most of the fuel seeped into the snow, which effectively trapped the fuel vapours. The fire was most intense in the forward left area of the fuselage, as evidenced by the complete destruction of this area; in contrast, a good portion of the right side of the fuselage was not burned to the same extent.

It is the evidence that two Dryden airport crash fire rescue (CFR) fire trucks arrived at the McArthur Road and Middle Marker Road location at approximately 12:18 (Red 3) and 12:19 p.m. (Red 1). The Unorganized Territories of Ontario (UT of O) rapid attack vehicle arrived at the scene at approximately 12:34 p.m., and the UT of O tanker truck arrived at approximately 12:40 p.m. Red 2 (CFR) arrived at approximately 12:43 p.m. At 12:44 p.m., two Town of Dryden fire trucks arrived. Captain Roger Nordlund, the UT of O fire chief, arrived at approximately 12:45 p.m.

It is quite disturbing that, despite the presence of sophisticated fire-fighting equipment and many fire-fighters, no attempt was made to extinguish the fire until approximately 2:00 p.m., one hour and 50 minutes after the crash. Some time after 1:30 p.m., the UT of O pumper truck was driven from the intersection of McArthur Road and the Middle Marker access road, where it had been parked since about 12:35 p.m., down the Middle Marker access road to a point opposite to and approximately 360 feet from the crash site. A handline from the truck was then dragged by eight to ten volunteers through the bush to the site, and fire retardant was applied to the fire at approximately 2:00 p.m. Fire-fighters continued to suppress small flare-ups for about another hour. At 6:00 p.m. the pumper truck and portable pond (port-a-pond) were moved closer to the crash site via a newly bulldozed road. Fire-

fighters remained at the site until about 11:30 p.m., and UT of O fire-fighters returned to the site during the next two days to ensure that further fire did not break out. Crash fire rescue is the topic of chapter 9 of this Report, Dryden Municipal Airport Crash, Fire-fighting, and Rescue Services.

The Fokker F-28 Mk1000 aircraft was approved in the transport category by Transport Canada on August 3, 1972, and, accordingly, was issued Canadian Type Approval No. A-108. Among other standards, the following standards applied: CAR 4b, dated September 1962, amendments 4b-1 through 4b-16, inclusive; and FAR 25, amendments 25-1 through 25-12, inclusive, 25-14 through 25-22, inclusive, and 25-24.

Accordingly, cabin materials on the F-28 aircraft, including seats and interior panels, were required, by type approval, to comply with the flammability standards of FAR 25 amendments no. 25-15 and no. 25-17, which, respectively, introduced the vertical Bunsen burner test and clarified the application of the standard with respect to specific materials and components.

Since the F-28 is a large aircraft used in commercial service, ANO Series VII, No. 2, applied. It required, in accordance with the Flammability Requirements for Aeroplane Seat Cushion Order (ANO Series II, No. 28, promulgated on June 6, 1986), that seat cushions comply with the flammability requirements introduced in FAR 25 by amendment no. 25-59, issued on October 26, 1984.

On July 21, 1986, the FAA issued two regulatory amendments: amendment no. 25-61, establishing upgraded flammability standards, and amendment no. 121-189, regarding implementation of the new standards. Because of industry feedback regarding the repeatability of the tests and the compliance times, and after further research and testing, the FAA issued, on August 25, 1988, amendments no. 25-66 and no. 121-198. These amendments established refined test procedures and apparatus to improve test repeatability, added a smoke emission test requirement and criteria to minimize the possibility that emergency egress would be hampered by smoke obscuration, and incorporated provisions for additional compliance time for unique components for which timely compliance could not be achieved.

Transport Canada has attempted to adopt the new FAA standards for cabin interiors in the proposed Improved Flammability Standards for Compartment Interior Materials Order (ANO Series II, No. 32). As of October 1, 1991, ANO Series II, No. 32, had not been promulgated; therefore, it was not applicable to the F-28 aircraft C-FONF.

Combustibility of Materials

The seat materials in C-FONF met the specifications requirements set out

in Air Navigation Order (ANO) Series II, No. 28, which require that the materials in aircraft such as the F-28 meet the fire-protection standards as indicated in Federal Aviation Regulation (FAR) 25.853(c). The material standards deal with such matters as ease of ignition, rate of flame-spread, ability to self-extinguish, flame drippings, and toxicity of fumes given off during burning. Transport Canada inspectors approved the aircraft's seats for compliance on December 30, 1988.

Because of the difficulty in tracing the history of C-FONF, the exact description of the interior furnishings of the aircraft could not be determined with certainty. During the time Air Ontario operated C-FONF, the aircraft was fitted with new seat material and new carpets. There is no evidence that the aircraft interior was ever refurbished with other new cabin materials, and it is assumed that, except for the seats and carpets, the materials in the aircraft at the time of the accident were as described by Fokker Aircraft B.V. as being in the aircraft at the time of initial delivery. As in most modern aircraft, the interior furnishings of C-FONF consisted primarily of plastic materials. The following is a description of the predominant materials found in the cabin at the time of the crash, and their use:

- acrylonitrile butadiene styrene (ABS): sidewall panel trim and the blinds and retainers
- polyvinylchloride (PVC): decorative sheet-covering of sidewall panels and partition walls
- nylon (polyamides): window supports
- acrylics (PMMA): outer and inner window panes
- glass fabric epoxy laminate and nomex: sidewall panels, partition walls, and cargo-hold liners
- chloroprene rubber: window seals
- tedlar-covered glass fabric epoxy sandwich, nomex core: ceiling panels and hat-rack liner
- polycarbonate: ceiling light covers
- modified polyphenylene oxide (PPO, called Noryl): passenger service unit panels, speaker panels, airduct panels, blind panels
- neoprene: seat cushions
- aluminum: hat-rack frames, floor panels.

Thermoplastics (ABS, PVC, PPO, PMMA, and polycarbonate) made up the major part of the interior furnishings. These plastics normally have higher ignition temperatures than wood products but can be easily ignited with a small flame and will burn vigorously. The rate of flame-spread of burning plastics is as high as two feet per second, about 10 times greater than the flame-spread for burning wood. The smoke generated by burning plastics is dense, black, and sooty. Chemicals

added to plastics to inhibit flammability often result in more toxic contaminants in the smoke. By-products of burning plastics are often toxic chemicals such as carbon monoxide (CO), hydrogen cyanide (HCN), hydrogen chloride (HCl), phosgene (benzine, toluene, styrene), and acrolein. Plastics subjected to heat and flame will melt, flow, and drip, causing burns to people and starting secondary fires. During his testimony, Mr Ricardo Campbell, who was a passenger in seat 7D on the right side of the aircraft, stated that molten burning material from the overhead bins dripped on him and the baby Podiluk after the aircraft came to rest. The chloroprene rubber (window seals) and the neoprene material of the seat cushions have fire characteristics similar to natural rubber. Overall there was not much rubber in the window seals, and the seat cushions burned very slowly because of their fire-inhibiting qualities. The contribution of the rubber products, the epoxy, and the aluminum to the lethality of the fire and its by-products was considered minimal compared with the contribution of the plastics.

Having reviewed all the evidence concerning the crash survivability of this accident, I conclude that the high survival rate in this severe crash was due to unpredictable and uncontrollable factors such as:

- daylight conditions,
- the heavy snow cover on the downsloping terrain, and
- the breaking apart of the aircraft during the final crash sequences, thus allowing many occupants to escape the wreckage and the fire.

Combined with the investigation problems associated with the near-total destruction of the aircraft by impact and fire, these factors preclude me from making technically specific safety recommendations with regard to crash survivability.

Findings

- During the crash, g forces in the aircraft reached 15 to 20 g, with local forces reaching perhaps 34 g.

- The breakup patterns of the F-28 aircraft, C-FONF, were all consistent with the overall assessment of the impact dynamics, and there was no observed pattern that, in an engineering design sense, was considered to be of an unexpected nature or that could not be explained. Therefore, I find that there is no evidence of fault in the design and integrity of the F-28 aircraft.

- Aircraft interior furnishings burned and gave off heavy sooty smoke and toxic gases; and burning, molten–plastic-like material fell on passengers.

- The clothing and slip-on shoes worn by flight attendant Sonia Hartwick did not afford her adequate protection after the crash. The weather was cold, and Mrs Hartwick lost her shoes in the crash.

- Passenger seats were deformed and many were detached from the aircraft floor and bunched in the front of the cabin after the crash.

- Overhead racks fell on at least 19 passengers.

- Many survivors of the crash were hindered in their escape by debris in the aircraft; some of the debris was certainly carry-on baggage from the overhead racks and from under the aircraft seats. (The subject of carry-on baggage is dealt with in chapter 24 of this Report, Flight Safety.)

RECOMMENDATION

It is recommended:

MCR 39 That Transport Canada press for the adoption of standards for aircraft interiors that would prevent the rapid spread of fire and the emission of toxic fumes.

12 FOKKER F-28, Mk1000, AIRCRAFT PERFORMANCE AND FLIGHT DYNAMICS

Mr Ralph E. Brumby, principal engineer, aerodynamics, Douglas Aircraft Company, in an article written in 1979, discussed wing surface roughness and aircraft performance:

> Most flight crew members and investigators are aware of the highly adverse aerodynamic effects of large amounts of wing surface roughness, such as the irregular shapes that can form on the leading edge during an icing encounter. However, what is not so popularly known is that seemingly insignificant amounts of wing surface roughness can also degrade flight characteristics ... roughness caused by frost, snow or freezing fog adhering to the wing surface, large accumulations of insect debris, badly chipped paint, or a distribution of "burred" rivets over the wing surface.
>
> (Exhibit 532, tab 11, "Wing Surface Roughness, Its Causes and Effects," *DC Flight Approach* (January 1979), 32)

A number of witnesses on board C-FONF on its final flight provided testimony as to their observations of snow and ice on the aircraft wings prior to takeoff at Dryden. These witnesses, and others, described in general terms the aircraft flight performance on takeoff and its flight path. Their descriptions greatly assisted the investigators and this Commission in determining what might have caused the F-28 aircraft to perform the way it did and, more importantly, why it failed to perform in a normal manner during its takeoff roll and its brief flight.

The most important and useful sources of information available for the investigation of aircraft flight dynamics and performance are the aircraft flight data recorder (FDR) and cockpit voice recorder (CVR). Because the recorders in C-FONF did not survive the fire, it was necessary for this Commission of Inquiry to pursue other avenues to determine what caused the flight profile of C-FONF.

It was the expressed view of the surviving crew member; of numerous passengers on the ill-fated aircraft, among them two professional airline pilots; and of a large number of observers on the ground, many of them pilots, that snow and ice adhering to the upper wing surfaces of C-FONF was the physical cause of the crash. The evidence of these witnesses, coupled with a thorough investigation by CASB investigators seconded to my Commission, left virtually no doubt that there was substantial

contamination adhering to the upper wing surfaces during takeoff. The aircraft accident investigative process required and the mandate of this Commission of Inquiry demanded that a detailed and thorough analysis be conducted to determine the degree to which surface contamination affected the flight dynamics of C-FONF and whether performance of the aircraft degraded to the point that the aircraft was unable to maintain flight.

I stated in Part 2 of my first *Interim Report*, in the section dealing with wing contamination, that:

> The adverse effects on aircraft performance and handling qualities caused by contamination of an aircraft's lifting surfaces, as described by the professional pilot witnesses in their evidence, whether due to snow, ice, frost, or other contamination, are well documented and universally known in the aviation community (p. 25).

In the following section, on safety awareness, I stated:

> It is a matter of particular concern that, despite the existence in many countries of applicable laws which prohibit takeoffs with contaminated aircraft-lifting surfaces, and despite the existence of similar prohibitions in the flight operations manuals of many Canadian aviation companies, icing-related accidents on takeoff continue to occur. A possible explanation is that air and ground crews are not sufficiently aware of the insidious hazards of ice, snow, and frost contamination to aircraft surfaces and the accompanying performance degradations (p. 28).

The fact that the experienced crew of C-FONF departed from the Dryden airport terminal and elected to take off in weather conditions that not only suggested but also should have red-flagged, even to a pilot far less experienced than Captain Morwood, the possibility of snow- and ice-contaminated wings, clearly indicated to me either an incomprehensible and deliberate disregard by the flight crew of these obviously dangerous conditions or, more probably, a failure to appreciate fully the adverse effects of the cold-soaking phenomenon and the problems of performance degradation caused on takeoff by contaminated lifting surfaces. These problems are discussed elsewhere in this chapter.

In order to investigate properly the flight dynamics of the Fokker F-28 Mk1000 aircraft and to determine how wing surface contamination affected its takeoff performance, a performance subgroup of the investigation team's operations group, consisting of experts in aerodynamics and aeronautical engineering, was formed. The subgroup was chaired by Mr Donald J. Langdon, a systems engineer with the Canadian

Aviation Safety Board (CASB), now the Transportation Safety Board of Canada (TSB), located at Uplands Airport, Ottawa, Ontario.

When the investigation of this aircraft accident, commenced by CASB, was assumed by this Commission of Inquiry, I sought and obtained the assistance of highly qualified experts not normally involved in aircraft accident investigation. Collaborating on investigating and researching the flight dynamics of the Fokker F-28 Mk1000, and in preparing a report on that subject, were Mr J. Murray Morgan, a physicist, an engineering test pilot of National Aeronautical Establishment (NAE) at National Research Council Canada (NRC), and an expert both in human performance in the cockpit and in computer-generated simulations; Mr Richard H. Wickens of NAE at NRC, an aerodynamicist specializing in low-speed aerodynamics; and Mr Gary A. Wagner, a pilot with Air Canada, a member of the Canadian Air Line Pilots Association (CALPA), an aeronautical engineer, and an adjunct assistant university professor lecturing in aerodynamics. I am indebted to these highly specialized individuals, recruited by Mr Langdon, for providing this Commission with a thorough and in-depth analysis of aircraft flight dynamics and performance issues.

Assisting in aircraft performance matters for my Commission were Mr David G. Rohrer, a CASB accident investigator seconded to my staff as a technical adviser, and Captain Allan Murray, a senior airline captain with Canadian Airlines International, who has extensive experience flying the F-28 Mk1000. Mr Rohrer was the chairman of the operations group; Captain Murray, a member of that group, participated on behalf of CALPA, which prepared an operations group working paper and thereafter the operations group's report.

Because witnesses had observed snow and ice on the wings of the aircraft and because of the concerns that my investigators had at an early stage of the investigation regarding ice contamination, Mr Langdon, again on behalf of my Commission of Inquiry, also requested the assistance of the low-temperature laboratory of NRC. Dr Myron M. Oleskiw, a research meteorologist with expertise and experience in studying ice accretion on air foils, fulfilled the request to determine the process of accumulation and adherence of precipitation on the aircraft surfaces.

I note that CASB sought on a number of occasions the assistance of both NRC and NAE and has cooperated on an informal basis with them on matters such as ultralight and amateur-built aircraft flight testing, helicopter crashes, FDR interpretation and transcription, development of computer software for the readout of FDR tapes, and fuel and lubricant analysis. I commend this type of cooperation, and I strongly urge and recommend that the TSB continue in the future to elicit and use the valuable expert resources of NRC and NAE.

Background

During the first week of May 1989, the members of the operations group travelled to Charlotte, North Carolina, and to Tampa, Florida, to visit Piedmont Aviation Inc. and USAir ground- and flight-training centres. Piedmont Aviation Inc. was purchased by USAir in early 1987, and over the next two years USAir and Piedmont Aviation Inc. merged their operations, completing the system merger by the summer of 1989. Unless specifically referring to USAir, I will refer to the collective operation of Piedmont Aviation Inc. and USAir as Piedmont Airlines or simply Piedmont.

The purpose of the group's visit was to review in detail the Fokker F-28 flight crew ground-training course given by Piedmont, under contract, to members of a number of Air Ontario Fokker F-28 flight crews, including Captain George Morwood and First Officer Keith Mills. Mr David Adams, this Commission's human factors expert, who worked with the operations group, was among those examining Piedmont's flight attendant crew training. While there, the operations group also reviewed Piedmont's progress and training records for Captain Morwood and First Officer Mills and met with the ground school instructor who had taught the two pilots.

In addition, some of the team members flew Piedmont's Fokker F-28 Mk1000/4000 aircraft flight simulator in Tampa to attempt to duplicate the performance and the flight profile of aircraft C-FONF as described by witnesses and estimated from initial accident investigation information.

Investigators' examination of the aircraft wreckage indicated that there were no mechanical malfunctions, nor was there evidence of engine power loss. Review and examination of the available weather data indicated that a low-level wind shear phenomenon was unlikely.[1] Witnesses did, however, describe both snow and ice on the wings. Witness statements and flight path reconstruction data indicated a flat flight profile before the aircraft crashed, and witnesses described how the aircraft lifted off, settled back on the runway, and lifted off again at or near the west end of the runway.

The flight investigation team consisted of Mr Rohrer; Mr Ronald Coleman, a CASB accident investigator; Captain Allan Murray; and Captain Robert Nyman, a senior F-28 qualified pilot with Air Ontario

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[1] A wind shear is an atmospheric condition in which the wind velocity vector (the wind speed and direction) changes significantly with small changes in the horizontal or vertical position. On takeoff, a wind shear could result in a significant performance loss if the aircraft climbed into a rapidly decreasing head wind, a rapidly increasing tail wind, or a strong vertical down draft.

and a member of the operations group. Together with the assistance of Piedmont Airlines, the team programmed various performance parameters into Piedmont's Fokker F-28 flight simulator and flew 30 takeoff profiles to identify factors that may have caused the aircraft to perform in the manner observed by witnesses.

The simulator is capable of simulating flight with a fidelity that meets Canadian and United States regulatory standards. The team was specifically interested in the modes of flight necessary to duplicate such flight anomalies as power loss, slush on the runway, wind shear, and mechanical malfunctions. Runway contamination could be simulated, but wing contamination could not.

During the tests by the operations group, the simulator was flown by Captain Nyman of Air Ontario and Captain Allan Murray of Canadian Airlines International, both qualified F-28 pilots.

The investigation team performed all takeoff profiles from a standing start on the runway using rated power and a flap setting of 18°. Airport elevation, runway length, and ambient temperatures and pressures similar to those at Dryden at the time of the accident were programmed into the simulator. Aircraft performance was measured at varying runway-contaminant depths of up to one-half inch of slush.

In addition to conducting the takeoffs from a slush-covered runway, the team flew a number of takeoffs, each time adding or changing factors that would progressively decrease the performance capability of the aircraft. In separate flights, one engine was failed at critical engine failure speed (V_1), wind shear was created by simulating a 30-knot tail wind at V_1, the aircraft was rotated at excessive rates and over-rotated to greater pitch altitudes than recommended, and the simulator was programmed to prevent the aircraft from rotating further than 6° pitch angle.[2] In each case where one of the factors was simulated, there was no significant degradation in performance and the aircraft completed its takeoff without difficulty.

The operations group concluded that the aircraft type performed well and had more than adequate thrust to operate from a 6000-foot runway at the estimated gross weight of C-FONF, and at the temperatures,

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[2] V_1, the takeoff decision speed, is computed for each takeoff and is, in general terms, the speed below which the takeoff should be rejected should an engine failure occur and above which the takeoff should be continued. V_1 is computed so that should an engine failure occur at or before that speed on a limiting runway, there would be adequate runway to stop the aircraft. Furthermore, should the engine failure occur at or after V_1 and the pilot continue the takeoff, the aircraft would be safely flyable and have a performance level that would allow the aircraft to reach a height of at least 35 feet over the end of the runway. A number of other complex criteria are involved in the V_1 concept and certification rules, but the above provides the general concept and purpose behind the V_1 takeoff decision speed.

pressures, and wind conditions present at Dryden on March 10, 1989. However, the Piedmont flight simulator was not highly calibrated, and, after analysing the results of the flights, the operations group realized that more in-depth study was necessary.

In order to inquire further into the performance of the Fokker F-28 aircraft, members of the operations group travelled to the aircraft design and manufacturing facility of Fokker Aircraft B.V. at Schiphol Airport, Amsterdam, The Netherlands. There they met with a number of Fokker's technical authorities, including Mr Rinse Jellema, Mr Frans Hollestelle, and Mr Jack van Hengst.

Mr Jellema, an aeronautical engineer, is the manager of the fleet airworthiness department, which is responsible for Fokker's fleet airworthiness, quality assurance, and safety investigations. He represented Fokker Aircraft during the early stages of the investigative process and assisted CASB's Engineering Branch in its examination of the aircraft wreckage and in dealing with the crashworthiness aspects of the aircraft crash.

Mr Hollestelle, who is Fokker's operations engineer, flight crew training and operations support, reviewed with the operations group the F-28 performance data and the operational capabilities of the aircraft and assisted in determining the performance capability of the aircraft by using the information available to the flight crew of C-FONF at Dryden prior to its takeoff and crash.

Mr van Hengst is the chief aerodynamicist and the manager of the aerodynamics and aeroelasticity department of Fokker Aircraft. He worked on the design and the development of the original Fokker F-28 Mk1000 and subsequent series F-28 aircraft, worked on the development of the Fokker-100 aircraft, and has participated in several research projects conducted by Fokker Aircraft unrelated to the F-28 and the Fokker-100 aircraft programs. Mr van Hengst provided to members of the operations group and the performance subgroup historical data on the design and development of the F-28 Mk1000 aircraft, together with aerodynamics studies relating to airfoil surface roughness and wing contamination. Fokker Aircraft also shared with my Commission investigators its collective knowledge of contamination-related accidents experienced by the Fokker F-28 over the years.

Manufacturer's Performance Research and Testing

The Fokker F-28 Flight Handbook was prepared by Fokker Aircraft B.V. (Fokker Aircraft or Fokker) to provide flight crew members as well as operations staff with a manual containing all information regarding

operations and performance. This handbook consists of three volumes. Volume 1 includes operating information; volume 2, certified performance information; and volume 3, additional performance information. The general performance information set out in the handbook is presented to comply with the appropriate performance criteria and certification requirements of United States Special Civil Air Regulation No. SR-442B.

The procedures, techniques, and other conditions detailed in these manuals were developed and recommended by Fokker Aircraft and approved by the Rijks Luchtvaart Dienst (RLD), the Dutch airworthiness regulatory authority, for use in the operation of F-28 aircraft. Fokker emphasizes that the procedures are only for guidance in identifying acceptable operating procedures; they are not considered mandatory so as to prohibit operators from developing their equivalent procedures.

Accordingly, manuals such as Piedmont Aviation Inc.'s F-28 Operations Manual, USAir's F-28 Operations Manual (also referred to as USAir's Fokker F-28 Pilot's Handbook), and the draft F-28 Operations Manual prepared by Air Ontario are examples of equivalent procedures developed by operators to fit their operations. In no event, however, may the F-28 operations manuals prepared and developed by operators be less restrictive than the procedures, techniques, and other conditions contained in Fokker's F-28 Flight Handbook.

In certifying the F-28, Fokker Aircraft elected to meet the requirements of the United States Civil Aviation Regulation 4(b) (CAR 4(b)), now called Federal Aviation Regulation 25 (FAR 25). The Dutch RLD adapted and conformed to the United States CAR 4(b) and FAR 25 as its certification requirements and standards. Fokker Aircraft also met the equivalent British Civil Aviation Regulations (BCARs) in its certification process.

An examination of the applicable legislation and a review of the evidence by this Commission confirmed that the aircraft met all the requirements of CAR 4(b) (and now FAR 25) and of the BCARs; accordingly, the aircraft met the applicable equivalent Canadian legislation for the purposes of operation in Canada. I am also satisfied that, since the aircraft met the requirements of Dutch CARs, United States CARs and FARs, and British CARs, Transport Canada was in a position to issue the appropriate certificate of registration and certificate of airworthiness for the Fokker F-28 Mk1000, Canadian registration C-FONF.

Water/Slush Ingestion by Engines on Takeoff

The flight crew of a NorOntair Twin Otter took off from the Dryden airport at approximately 12:50 p.m. on March 10, 1989, approximately 39

minutes after the crash of C-FONF. In testimony before this Commission, members of the crew described the amount and type of contamination at the terminal ramp and on the east half of runway 29 to be one-quarter to one-half inch of slush at that time. Two witnesses on the ground heard engine noises coming from C-FONF during its takeoff run that they variously described during testimony as "burping," "sharp," "explosive," and "quick" then "gone." In view of this evidence, it was deemed necessary to determine if the noises described by these two witnesses might have been caused by slush ingested into the engines during the aircraft's takeoff run.

In order to comply with the United States FAR 25.1091–type certification requirements, Fokker Aircraft was required to design and locate the engine air inlet ducts on the F-28 aircraft in such manner as to minimize the ingestion of foreign matter during takeoff, landing, and taxiing, and it had to demonstrate that the design of the aircraft precludes a hazardous quantity of water and/or slush on the runway from being directed into the engine inlets. The evidence shows that flight and ground-run tests were conducted in natural slush conditions at Schiphol Airport in Amsterdam on February 5, 1968, with Dutch RLD observers present.

Fokker, in its certification report no. V-28-7, dated March 11, 1968, and entitled "Investigation on F-28 Slush Ingestion Characteristics," described the tests, the test results, and the conclusions. The tests consisted of one takeoff with 25° of flap selected and two ground-run accelerate-stops with, respectively, 42° and 25° of flap. During the tests, the spray patterns were observed from inside the aircraft and observed and photographed from two observation posts alongside the runway. There were large variations in the density and depth of the slush layer. The first part of the runway, where the aircraft was accelerating, was covered with patches up to two inches thick of relatively dry snow and low-density slush. On the portion of the runway where the aircraft passed at high speed or was stopping, the predominant condition was high-density slush, one-quarter to one-half inch thick. The temperature was slightly above zero. There were water deflectors on the nose tires.

Spray from the nose wheels emerged in the shape of a flat, narrow disc and passed beneath the wing and the fuselage between the main undercarriage struts. A small amount of slush deposit was found on the nose-gear doors and the underside of the fuselage aft of the nose-wheel well. This secondary spray from the nose tires was effectively blocked from the engine intakes by the fuselage. No spray from the nose tires was seen to pass over the wing or into the intakes. The spray from the main wheels had a similar shape and, apart from a small jet of slush emerging at a steeper angle from between the two wheels of each main undercarriage strut, passed well below the plane through the underside

of the aft fuselage. The jet of slush was effectively prevented from entering the intakes by the inboard sections of wing and flap.

It was concluded that, under conditions representative of slush conditions that can be expected in airline service, the design of the aircraft precludes a hazardous quantity of water and/or slush from being directed into the engine intakes. Since there was no observed ingestion, Fokker concluded that the tests also showed that the location of the engines is also favourable in minimizing the ingestion of other forms of runway contamination.

Fokker provided to this Commission certification report no. V-28-7, together with photographs taken by Fokker, which describes and demonstrates the testing and conclusions. Shown below as figure 12-1 is one of the photographs provided by Fokker Aircraft showing the F-28 during slush tests moving at high speed in slush. Mr van Hengst, who was present during the tests, described in detail during his evidence before the Commission the findings of Fokker Aircraft. He also advised that he is not aware of any operators who have reported contamination entering the engines on slush-covered runways.

Mr van Hengst testified that, at a flap setting of 25°, slush lodged between the flap and the flap vane, a condition Fokker considered might cause damage on flap closure. Accordingly, Fokker, to avoid damage to the flap vane system due to the slush compaction between the flap and vane, recommended that takeoffs in slush be conducted at an 18° flap setting. Fokker in evidence showed that flaps set at 18° provide a shielding effect similar to a 25° setting but without exposing the flap and vane to slush compression damage.

There is some possibility that snow, slush, or ice that left the wing upper surface during the takeoff run was ingested into the engines. The Piedmont operations manual, in the section on adverse weather, contains information regarding ice that may form on the upper surface of the wings while the aircraft is on the ground. The ice forms either because of warm fuel, which can cause snow to melt, with the water subsequently refreezing; or because of extremely cold fuel, as may be the case after long flights at very low ambient temperatures, which causes water condensation or rain to freeze. It is stated in the manual that "[d]uring take-off this ice may break away and at the moment of rotation enter the engine causing compressor stall and/or engine damage" (p. 3A-24-1). During testimony, however, no one described seeing anything that could be taken to be unusually large amounts of ice or snow separating from the wing of C-FONF during the takeoff roll. Moreover, there was no damage found during examination of the engines that showed they had ingested slush or ice. (For details, see the section on engine investigation in chapter 10 of this Report, Technical Investigation.) During manufacturer's certification tests of the F-28 Rolls-

Figure 12-1 F-28 during Slush Test, February 5, 1968

Source: Fokker Aircraft B.V.

Royce engines, as described in chapter 10, it was demonstrated that the engines were able to ingest great quantities of water with no apparent difficulty. Bearing this point in mind along with the fact that most witnesses testified that the engines were operating normally throughout the takeoff run, it is probable that if the engines ingested snow, slush, or ice from the wings during takeoff, the ingestion could have caused only a fleeting abnormality and perhaps an uncommon noise.

From the evidence that I have heard and the documents reviewed, I am satisfied that, during the takeoff run of C-FONF from the Dryden airport on March 10, 1989, slush from the runway was not ingested into the aircraft's engines. If contamination from the aircraft wings had been ingested, it would not have caused a reduction in thrust or a failure of the engine such as to affect tangibly the takeoff performance of the aircraft.

Wing Leading-Edge Damage

Denting

Commission investigators were advised that the wing leading edges of one or both of Air Ontario's F-28 aircraft may have been dented. Since a smooth leading-edge surface is critical to the production of lift, my investigators felt it was important to make inquiries to determine if there was denting on the wing leading edges of C-FONF. They also approached Fokker Aircraft to determine the effects that denting on the wing's leading edge has on aircraft performance. Information on this subject was also solicited during the appearance of Air Ontario pilots on the witness stand. Some of the pilots recalled having some knowledge of denting on the wings of the F-28 aircraft, but only one stated that there were dents on aircraft C-FONF. Captain Monty Allan, a first officer on the F-28 at the time of the accident, stated that he was aware of dents on the wings, particularly of a fist-sized dent on the leading edge of C-FONF. Since the dents were written up in appropriate logbooks and apparently were not repaired, he believed the dents were within allowable limits. None of the other pilots was sure of the size or position of the dents. Ms Elaine Summers, the chairwoman of the investigation team's records group, stated in testimony that, while examining aircraft C-FONG after March 10, 1989, in relation to another incident, she noted some dents on the leading edge of the left wing.

Fokker Aircraft advised that on August 15, 1971, an F-28 aircraft operated by Martin's Air Charter encountered hail in flight at 230 knots at an altitude of 10,000 feet. The leading edges of the wings, the empennage (tail section), and the engine inlets were dented, and the fuselage nose was worn. The maximum depth of the dents was about 4 mm, and there were about 25 dents per m span of the wing. The

structural integrity of the leading edges was not impaired, and continued flying was permitted by the Dutch RLD, provided Fokker could show that the aerodynamic capabilities were not downgraded. (The wing was required still to be able to generate the maximum lift coefficient (C_{LMAX}) as certified for the aircraft.)

On August 16, 1971, a test flight was flown on the aircraft, during which flight stall tests were performed to assess the maximum lift coefficient and the stalling characteristics. The flight was flown by a Fokker test pilot, and an F-28 captain with Martin's Air Charter acted as co-pilot. Observers on board included individuals from the Dutch RLD and Fokker's aerodynamics department. The testing revealed no measurable effect on the maximum lift coefficient and the stalling characteristics due to the dents in the leading edges of the wings.

In the report of the testing, Fokker described the hail encountered and the test results. The aircraft's stalling characteristics were found very satisfactory and not impaired whatsoever by dents in the leading edges of the wings. Fokker concluded in the report that, based on the indicated angle of attack during the tests, the g-break lift coefficients in the aircraft were at least equal to the g-break lift coefficients when the aircraft was certified and, most likely, were better.[3]

It is the evidence of Mr van Hengst that this report, generated as a result of the test flights, was used by Fokker Aircraft as a basis for the configuration deviation list (CDL) for the F-28, which specifies the amount of denting allowed on the leading edge of the wing. To summarize Mr van Hengst's evidence, basically the CDL stated that the amount of allowable denting on the leading edge of an aircraft wing can be no more than an amount equal to 25 per cent of the dents found on the test aircraft and that the maximum depth of any one dent was 4 mm. In determining the CDL requirements, structural integrity of the wing as well as aircraft performance was taken into consideration.

Mr van Hengst in his evidence discussed other types of denting on leading edges. He concluded that sharp dents in the leading edge of the wing would have the greatest effect on lift, with smooth dents on the trailing edge having no effect. Apart from those tests described in the aerodynamics report provided to this Commission, Fokker conducted no other tests relating to the effects of dents on aircraft wings. Since Mr van Hengst's views on the effects of denting on the leading edge are important, I include the following quotation:

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[3] In ground terms, g-break is the point where an aircraft can no longer maintain one-g level flight. That condition is used during certification test flight to define the aircraft stall speed and corresponding maximum lift coefficient (C_{LMAX}).

A. ... When we did this flight test with the dents, deep in my heart, I thought it had an effect. And I learned a lot of it. I learned that maybe it has something to do with the sharpness and the steepness of the disturbance, and looking in all the data and wind tunnel testing done in the early days, that convinced me that that is a rule.

As long as the edge of the disturbance is not sharp but smooth, then the effect on the aerodynamics is mild. I won't say there is no effect. It depends on the place where it is. If it is on the leading edge, there will be effect. If it is on the trailing edge, there will be no effect.

Q. And if they are sharp, if the dents are sharper?

A. If it is sharpened, it's worse. That's the worst thing ... you can have.

(Transcript, vol. 71, p. 147)

Mr van Hengst also responded to a question about the effect of the dents on adhesion of contamination to the leading edge of a wing:

A. I – well, I'm not a [physicist], but if you look at the mechanism, if the precipitation is simply rain, it doesn't matter whether the surface is smooth, say a metal surface. As long as the temperature of the surface is cold, it will adhere. It will stick to the surface. And no matter whether it is [a] little bit roughened, it simply sticks.

(Transcript, vol. 71, p. 148)

Condition of the Paint

In order to complete the picture regarding the condition of the leading edges of the wings on the F-28 aircraft flown by Air Ontario, the Air Ontario pilots were questioned about the condition of the paint on the leading edges. During testimony, Captain Robert Perkins stated that he learned on the F-28 course that the F-28 aircraft was susceptible to leading-edge damage. He had noted some chipped paint on, he believes, C-FONF, and he stated that the paint on C-FONF was older than that on C-FONG. Captain Allan stated that the paint on C-FONF was peeling and flaking, and on C-FONG it was bubbling and blistering; the bubbles were "tiny, tiny, very small" (Transcript, vol. 91, p. 68), about the size of the tip of a pen. Captain Allan was never genuinely concerned about the leading-edge paint on the F-28 aircraft.

Mr van Hengst did not provide a detailed opinion on the aerodynamic effects of chipped paint on the wing leading edges. He stated that the wings should be kept as smooth as possible to minimize skin friction during flight. He also stated that the roughness on the wing from paint chipping and peeling is not especially significant and does not significantly affect lift characteristics.

While there may have been some denting and degradation of the paint on Air Ontario's two F-28 aircraft, I have no evidence before me to indicate that the condition of the wings' leading edges could have contributed appreciably to the degradation of the takeoff performance of C-FONF. I make this finding based on the fact that there was never any reported takeoff or performance degradation of either of Air Ontario's two F-28 aircraft during their operational lives. Accordingly, I do not believe that denting or chipped paint on the leading edges of the wings of C-FONF contributed to the performance degradation during its ill-fated takeoff run from Dryden on March 10, 1989.

Unexpected Stalling Due to Wing Anti-Ice Air Leakage

The matter of unplanned aircraft stalling while on approach for landing was brought to the attention of my investigators by members of the International Federation of Air Line Pilots Associations (IFALPA), who had observed unplanned stalling caused by leakage of hot anti-icing bleed air through joints in the wing's leading edge. The leaks cause the airflow characteristics to be modified. The partial flow separation that then occurs over the parts of the wings where the leaks appear adversely affects the aircraft stall characteristics. Accordingly, the matter was reviewed to determine whether this phenomenon may have occurred during the takeoff of C-FONF.

Both the Fokker F-28 Flight Handbook and the Piedmont and USAir operations manuals stress that wing anti-ice should not be put on during any phase of the takeoff or while the aircraft is airborne below 1500 feet above ground level. Wing anti-ice requires engine bleed air and results in a loss of some engine thrust. To ensure maximum available engine thrust during takeoff, pilots are advised not to use wing anti-ice during takeoff. Although the observations made by the IFALPA members related to flight at low speeds during the approach and landing with wing anti-ice on, my investigators took steps to determine if the wing anti-ice system was off during the takeoff at Dryden. This exercise was carried out to confirm that C-FONF had maximum thrust available during takeoff and also to eliminate any concern about possible wing stall due to wing anti-ice bleed-air leakage. The investigation confirmed that the wing anti-ice valves were in the off position after the crash and, owing to the absence of debris in the air passages of the anti-ice system, were in the off position during the time the aircraft was travelling through the trees.

It is unlikely that, owing to performance penalties which would have been suffered, the pilots would have used wing anti-ice in any event: C-FONF was being operated from a 6000-foot runway and the aircraft

weight at takeoff was close to maximum structural takeoff weight. Although there was observed wing drop shortly after takeoff, the aircraft was also observed to have regained a wing-level attitude.

There is persuasive evidence that the anti-ice system was off during the takeoff of C-FONF, and there is no evidence of previous wing anti-ice air leakage problems on either of Air Ontario's F-28 aircraft. The fact that the anti-ice valves were closed would eliminate any concern that air leakage had affected the flight characteristics of the aircraft. I am therefore satisfied that wing anti-ice air leakage was not a factor during the takeoff from Dryden.

Relevant F-28 Wing Surface Contamination Occurrences

To determine whether the F-28 aircraft had a history of contamination-related accidents, my investigators reviewed the aircraft type's accident history. The F-28 accident and incident record, as revealed in International Civil Aviation Organization (ICAO) and CASB occurrence data bases, is not unusual in any sense. The records do not indicate any particular trend, nor is there evidence of the aircraft having abnormal flight characteristics. On the contrary, the Fokker F-28 Mk1000 appears to have relatively good performance and is reportedly easy to fly.

Two occurrences involving wing contamination and the Fokker F-28 are significant to this investigation and warrant a detailed description of the circumstances and the findings. The first occurred in Germany, at the Hanover airport, on February 25, 1969, and the second occurred in Turkey, at the Cumaovasi airport in Izmir, on January 26, 1974.

Hanover, Germany, February 25, 1969

The crew of an F-28 aircraft attempted to take off from runway 09 left on a demonstration flight from the Hanover airport at about 1626 GMT (1726 local), February 25, 1969. Runway 09 left is 2387 m (7832 feet) long and 45 m (150 feet) wide, and it has no slope. The elevation of the airport is 170 feet above mean sea level (asl).

At rotation speed, the captain rotated the aircraft to about 12°, and the aircraft lifted off. It immediately rolled to the right to an angle of bank of about 25°, which could not be corrected by aileron control. The aircraft did not accelerate and descended until the right wing tip struck the runway. The aircraft rolled to the left and then to the right, and the captain rejected the takeoff. The aircraft came to rest approximately 50 m (164 feet) to the right of the runway and 1975 m (6480 feet) from where the takeoff roll commenced. The stick-shaker had activated three times while the aircraft was airborne. The only damage to the aircraft

was to the right wing, the flap, and the aileron. None of the two crew or nine passengers was injured.

Given the conditions at the time of takeoff, the aircraft should have reached rotation speed of 103 knots after a ground roll of 475 m (1558 feet) and become airborne at 113 knots. The Fokker F-28 Flight Handbook recommends that the aircraft be rotated to 5 to 10 on takeoff. From the flight data recorder it was determined that the aircraft was rotated at 105 knots after a ground roll of 535 m (1755 feet) and became airborne at 110 knots. The aircraft reached a maximum height of 50 to 60 feet and a maximum speed of 127 knots. The first stall developed three to five seconds after liftoff.

The captain held a valid airline transport pilot licence (ATPL) and had a total of 11,500 flying hours with recent flying experience on the Caravelle, the Hansa Jet, and the Nord 262 aircraft. He had a type rating on the F-28 with 12 to 14 hours on the aircraft. The co-pilot held a valid ATPL and had a total of 8000 flying hours. He had 10 to 15 hours on the F-28.

The aircraft was serial number 11004, registered as PH-ZAA, and was the fourth prototype and the first commercially operated aircraft of the F-28 series. It was owned by a German charter company (LTU). The aircraft was modified up to the latest standards of the production series and met Netherlands (RLD) requirements for airworthiness. There was no evidence that there had been any defects or malfunctions that had a bearing on the incident. The aircraft's weight and balance were within limits. The stabilizer setting for the flight had been set to 1° ANU (aircraft nose up); in the flight manual the recommended setting is 1° AND (aircraft nose down). The incorrect stabilizer setting would reduce the amount of control column force required to effect aircraft rotation.

The aircraft had been parked for about five hours preceding the attempted flight. During this time, the temperature was between 1 and 2°C, the relative humidity was near 100 per cent, there was overcast cloud based at 700 to 900 feet, and there was precipitation in the form of light snow and undercooled drizzle. At takeoff time, the temperature was 2°C and the visibility was 3 km in snow. The wind was 060° at 7 knots. The runway was covered with rime or ice but had been chemically de-iced and sanded during the day; the measured braking action was medium to good. The preceding takeoff had been made by a Viscount aircraft 15 minutes before the incident. On the basis of the weather, the investigators concluded that no wind shear, either in force or direction, existed, and that any turbulence from departing aircraft had dissipated.

During the pre-flight inspection, the captain and a factory mechanic noted that the precipitation had formed a thin layer of ice patches on the wing. The captain judged this accretion not significant enough to have it removed. It was later established that the ice was mostly at the nose

of the wing, back to approximately 30 per cent of the chord and extending over the full span of the wing. The accretion was described by the captain and mechanic as a thin, irregular layer of ice patches, the ice crystals being of a granular form. A passenger, while leaving the aircraft via an emergency exit over the right wing, had trouble keeping his balance because of ice on the wing.

Fokker Aircraft, which participated in the investigation, was able to assess the degree and amount of contamination on the wing. In terms of area covered by the contamination, Mr van Hengst stated in testimony as follows:

> A. It was distributed over the whole wing, and what also happened is that it stands there, and in the memory of one of the witnesses, at that early day in the morning, there was also between all this freezing drizzling the sun coming up. It was in the morning.
>
> And one of the parts of the wing was in fact already melting, and the other not. Because the aircraft was standing like this and the sun is coming like this so this part was starting to melt and the other one not.
>
> So ... what then happened is they took off and in fact, one of the wings was clean due to the sun and the other not, and that is the reason why it rolls off.
>
> (Transcript, vol. 70, p. 78)

During the takeoff, the aircraft was over-rotated. It was found that the stabilizer was incorrectly set, resulting in lower control forces at rotation. However, the maximum rotation angle that was reached, about 12°, would not have caused an F-28 with a clean wing to stall.

It was therefore concluded that the contamination on the wing, in the form of a thin, irregular sheet of granular ice crystals, must have been the factor that caused the wing to stall.

Fokker Aircraft determined that the roughness on the nose and upper surface of the wing was equivalent to ice particles of 1 or 2 mm in diameter, distributed approximately one particle for each square cm of wing surface.

Izmir, Turkey, January 26, 1974

The crew of a Turkish Airlines F-28 aircraft, serial number 11057 and registration TC-JAO, attempted to take off from Cumaovasi airport, Izmir, Turkey, at about 0710 local time, January 26, 1974. The aircraft became airborne after a ground roll of approximately 975 m (3200 feet); however, when it was 8 to 10 m (26 to 33 feet) above the ground, it yawed to the left and pitched nose down. The aircraft contacted the ground in a near-level attitude, first by the outboard fairing doors of the

left flap, then by the left side of the fuselage belly. The aircraft disintegrated and caught fire within 100 m (328 feet) of travel. Four crew members and 62 passengers died as a result of the accident; one crew member and 6 passengers survived.

With the conditions at the time of takeoff, the aircraft should have reached rotation speed after a ground roll of 850 m (2800 feet). From the flight data recorder it was determined that the aircraft became airborne at 124 knots after a 975 m (3200-foot) roll. The speed increased to 133 knots and then dropped to 124 knots, and the aircraft veered left.

The captain was an ex-airforce jet fighter pilot, held a valid airline transport pilot licence, had 577 hours in F-28 aircraft, and had 2600 hours' total flying time. He had been an F-28 captain since 1972 and an F-28 check pilot since 1973. The co-pilot was also ex-airforce, and his experience was in transport-type aircraft and helicopters. He had 395 hours in the F-28, had 2794 hours' total flying time, and held a valid airline transport pilot licence.

The aircraft broke into three main sections: the tail section, the fuselage, and the cockpit. The fuselage came to rest upside down. There was no evidence of any aircraft failure or malfunction prior to the accident.

The aircraft had been parked overnight in an open area of the airport. On the morning of January 26, the temperature was 0°C and the relative humidity 95 per cent. At the time of takeoff, the temperature was 3°C and the relative humidity 97 per cent. Frost formation was not noticed during the aircraft walkaround prior to the takeoff. The next day, however, with meteorological conditions almost the same, frost accumulation was seen on the wings of another F-28 parked outside overnight. There was more frost on the left than on the right wing, which was towards the buildings.

It was concluded that the cause, or probable cause, of the accident was that the aircraft stalled because of over-rotation and frost accretion on the wings.

Wing Contamination – Research

Following the February 25, 1969, F-28 takeoff occurrence at Hanover, Fokker reviewed early research on the subject of surface roughness on airfoils and conducted a series of wind tunnel and simulator tests. Fokker wished to confirm the findings of existing literature and determine the effects of apparently unobtrusive amounts of contamination on the ability of the F-28 wing to produce lift.

Literature published in the 1930s on the effects of protuberances and surface roughness on the characteristics of airfoils concluded that protuberances on the upper surface of an airfoil, so small they would

ordinarily be considered surface roughness, have a significant detrimental effect on the maximum-lift and drag characteristics. As the portion of such roughness approaches the leading edge along the upper surface, the effect becomes particularly critical.

Mr Richard Wickens, an expert in low-speed aerodynamics and one of the members of the performance subgroup, stated during his testimony that the data in the reports and memoranda of the 1930s indicate that, on smooth airfoils, smaller grain roughness has a greater detrimental effect on the lift than does larger grain. When asked if the literature is saying that more smoothly finished airfoils are more susceptible to lift reduction when subjected to some sort of roughness, Mr Wickens stated:

> A. That's what it appears to be saying. The ... more smoothly finished airfoil is capable of achieving higher maximum lift coefficients, and this curve is still going up. So that when you roughen them, you have a greater relative loss.
>
> (Transcript, vol. 69, p. 88)

Mr Wickens further stated that although there is not a great deal of lift capability lost when the rear portion is roughened, there is still some loss, although nothing like that seen when the complete airfoil, including the nose, is roughened. Mr Wickens stated as follows:

> A. There was one other point, and that is there are data points which indicated only the rear half of the airfoil in this case was roughened, and according to this, that appears to restore the performance back to its original clean state, with this exception.
> Q. So when only the rear half of the airfoil was roughened, the lifting capability was almost the same as it was with a totally clean surface?
> A. There was a slight loss, but it was nowhere near as much as with the complete airfoil roughened, including the nose.
> Q. So can I assume from this that the roughness on the front portion of the wing is more critical than the roughness on the back portion of the wing?
> A. Yes.
>
> (Transcript, vol. 69, pp. 89–90)

Mr van Hengst aptly summarized the conclusion of the early research reports as follows:

> A. Well, the basic conclusion which you can draw from this report is that contamination on a wing will give rise to loss in lift, and especially loss in maximum lift.
>
> (Transcript, vol. 70, p. 82)

Based upon this early research literature and the description by the flight crew and by the engineer who inspected the F-28 prior to its takeoff at Hanover, Fokker conducted wind tunnel tests using a scaled 20-to-1 F-28 model aircraft with both wings roughened and contaminated evenly on a scale of one 1 mm diameter particle for each square cm of wing surface.

Following the wind tunnel tests and studies conducted by Fokker Aircraft, the company produced a report, entitled "Note on the Aircraft Characteristics as Affected by Frost, Ice or Freezing Rain Deposits on Wings, December 16, 1969." Referred to as the "Wind Tunnel" report (no. L-28-222), it was forwarded at that time to all F-28 operators. The report deals with the effects of sandpaper roughness on the wings of both jet and propeller aircraft and specifically describes the degradation in takeoff lift and the acceleration characteristics of the F-28 caused by roughness on the wings. It is included in its entirety as technical appendix 5 to this my Final Report. An illustration of the F-28 model in a wind tunnel is reproduced as figure 12-2.

The tests revealed that there was a 25 per cent loss of maximum lift coefficient and that the maximum angle of attack was reduced by approximately 5°. Early experiments at cleaning contamination from the forward 50 per cent of the airfoil chord restored most of the lift characteristics. In an effort to determine more closely where the F-28 wing was most sensitive to surface roughness, Fokker removed roughness from the forward 15 per cent of the wing chord, starting at the leading-edge nose. Fokker found that the lifting capability of the wing was almost completely restored.

The wind tunnel tests also demonstrated that, with severe roughness, the wing can be stalled before it reaches the angle of attack that would normally activate the aircraft's stall-warning system.[4]

The horizontal stabilizer on the F-28 during normal operations, including takeoff, is designed not to exceed an angle of attack of approximately 7°. Fokker designed the horizontal stabilizer to guarantee continued controllability even when the wing is stalled.

Similar wind tunnel tests showed that contamination roughness on the horizontal stabilizer had little or no effect on its performance, even when the wing is stalled as a result of contamination. The tests confirmed that

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[4] A stall-warning system (SWS) is a system designed to alert a pilot to an impending aircraft stall. It consists of an angle of attack sensor(s), an aircraft configuration input data system, and a mechanical alerting mechanism, commonly a stick-shaker. The SWS is set to activate at a predetermined angle of attack a few degrees below the wing's normal stalling angle of attack. When activated, the stick-shaker vibrates the pilot's control column. Under normal conditions, activation is generally used to indicate the prudent limit of usable lift.

Figure 12-2 Wind Tunnel Model Used in the Design of the F-28 Mk1000 Aircraft

Source: Fokker Aircraft B.V.

contamination on the horizontal stabilizer would not have a significant effect on controllability and would not affect the total lift generated by the lifting surfaces. Generally, the horizontal stabilizer provides negative lift (the lower, uncontaminated surface is the critical surface), and the angle of attack of the stabilizer is well below its stalling angle of attack.

According to Mr van Hengst, the stall-warning device on the F-28 is activated at 11° wing angle of attack. Complete airflow separation where the aircraft loses aileron control occurs on a clean wing at a point between a 19° and 20° angle of attack. On a contaminated wing, however, complete airflow separation occurs with loss of aileron control at a 9° to 10° angle of attack. In other words, with roughnesses of 1 to 2 mm on every square cm of the entire wing, the aircraft will stall prior to the stall-warning device activating; in some cases, complete loss of aileron control could happen prior to such warning.

The results of the wind tunnel tests were fed into Fokker's engineering flight simulator to determine how the aircraft would behave with various degrees of roughness on the wings. The results were interpreted in various ways, but in every case the indication was a loss in the wing's ability to produce lift when contaminated. The two graphs that Fokker prepared from its engineering flight simulator data are included to demonstrate the loss of lift caused by varying degrees of wing contamination.

Up to a point, as figure 12-3 indicates, the more the wings were contaminated the greater the loss of lift. For example, during takeoff at a weight of 60,000 pounds, with 18° of flap and with a clean wing, the stalling speed of the aircraft was about 104 knots. With the wing lightly frosted, the stalling speed was about 117 knots, and with the wing heavily frosted, about 128 knots. The V_R speed (takeoff rotation speed)[5] for the aircraft was 121 knots and the V_2 (takeoff safety speed)[6] was 127 knots. With a clean wing, the speed margin at rotation speed before stall was approximately 17 knots. With a lightly frosted wing, the margin was 5 knots. With a heavily frosted wing, the wing was in a stalled condition as it was rotated.

Figure 12-4 describes the decrease in stall margin between a normally clean wing and a lightly frosted wing and demonstrates that an aircraft

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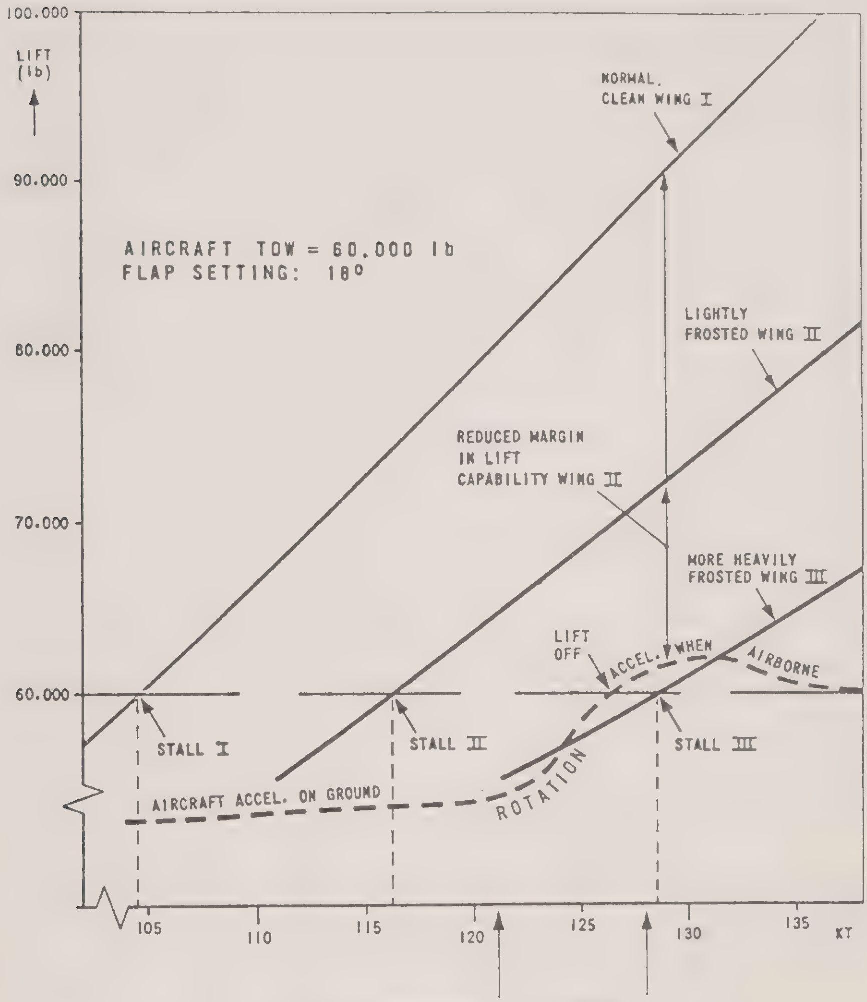
[5] V_R, the takeoff rotation speed, in general terms is defined as the speed at which rotation is initiated during the takeoff to attain V_2 climb speed at the 35-foot screen height. V_R must not be less than 1.05 times the minimum control speed in the air (V_{MCA}) or less than V_1.

[6] V_2, the takeoff safety speed, in general terms is equal to the actual speed at the 35-foot screen height as demonstrated in flight and must be equal to or greater than both 1.20 times the stall speed in the takeoff configuration and 1.10 times the minimum control speed in the air (V_{MCA}).

Figure 12-3 Comparative Margins for Two Arbitrarily Chosen Frost-Contaminated Wings and the Normal Clean Wing

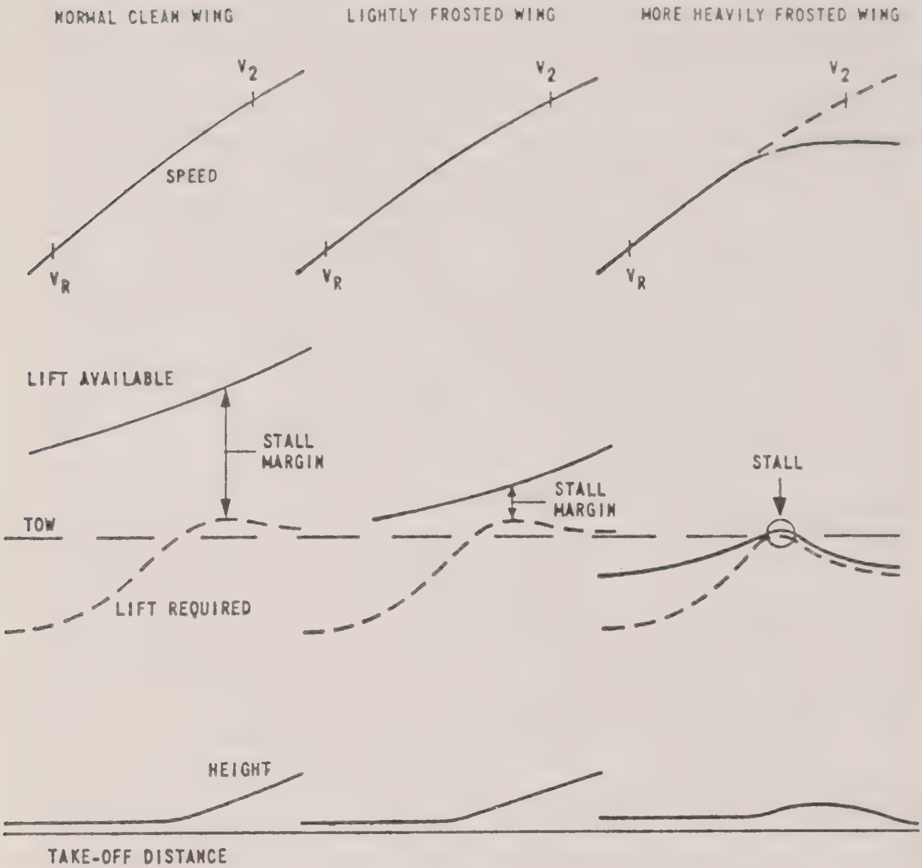


SPEED MARGIN TO STALL AT	V_R	V_2
WING I	16.5 KT	24 KT
WING II	5 KT	12 KT
WING III	–	–

Figure 1

Source: Shipwise (Fokker Aircraft), February 15, 1974

Figure 12-4 Comparative Stall Margins[1]



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[1] Illustrates differently the comparative stall margins for the same (figure 12-3) two arbitrarily chosen frost-contaminated wings and the normal clean wing.

Source: Shipwise (Fokker Aircraft), February 15, 1974

with more heavily frosted wings is unable to sustain flight because the wing is in a stall condition at rotation.

As a result of the research and testing, Fokker Aircraft concluded with an ominous warning printed in large capitals on a separate page: *"Since there is no way of measuring the amount of frost contamination in relation to its effect on the wing lift capability, get the aircraft de-iced before departure"* (Exhibit 532, tab 4).

Flight Dynamics of the Fokker F-28 Mk1000

Following the initial test flights conducted by the operations group in Piedmont's F-28 flight simulator, the group confirmed that a more detailed examination of F-28 performance was necessary to identify factors that could produce a takeoff profile similar to the accident profile at Dryden. As noted, some members of the operations group travelled to Amsterdam to visit Fokker Aircraft to compare the manufacturer's contract flight crew training program with that of Piedmont. At the time, the performance subgroup also attended at the Fokker Aircraft facility in Amsterdam to commence its study of the F-28 aircraft flight profile. This section of my Report is based upon two reports prepared as a result of these investigations.

The first report, "Flight Simulator Investigation into the Take-off Performance Effects of Slush on the Runway and Ice on the Wings of a Fokker 100," was issued in August 1989 by Fokker Aircraft B.V. Referred to as the "Flight Simulation" report, it summarizes Fokker's data and findings on the takeoff performance of a Fokker 100 engineering flight simulator adjusted to approximate the flight characteristics of an F-28 Mk1000 aircraft. (The "Flight Simulation" report was entered as Exhibit 544 during the testimony of Mr Jack van Hengst.)

The second report, entitled "A Report on the Flight Dynamics of the Fokker F-28 Mk-1000 as They Pertain to the Accident at Dryden, Ontario, March, 1989" (the "Flight Dynamics" report), was researched and prepared by Mr Murray Morgan, Mr Gary Wagner, and Mr Richard Wickens.

Mr Morgan, manager of the in-flight simulator in the flight research laboratory of NAE at NRC in Ottawa, is a physics graduate and engineering test pilot with extensive experience in real-time software and mathematical techniques. Mr Wagner, an Air Canada pilot and a member of CALPA, as well is a qualified aeronautical engineer and an adjunct assistant university professor. Mr Wickens, a senior research officer in the low speed aerodynamics laboratory of NAE at NRC, is a qualified mechanical engineer with a specialty in low-speed aerodynamics.

The team's objective was to re-create the flight profile of C-FONF on takeoff at Dryden on March 10, 1989, and to determine the conditions that could have caused such a profile. Their report, entered as Exhibit 526, was addressed by each author during his testimony.

I believe that the data contained in the "Simulation" and the "Flight Dynamics" reports provide, in detail and with clarity, a thorough review of wing contamination and aircraft performance research and findings, and I have included both reports in the technical appendices to this my Final Report. (The Fokker "Flight Simulation" report appears as technical appendix 3 and the "Flight Dynamics" report as technical appendix 4.) It is my belief that the aviation community, and in particular flight crews, will find the background and detailed information, the test procedures, and the graphics contained in these two reports to be of value in appreciating more fully the insidious nature of wing contamination.

Because some of the data contained in these reports are complex in nature, I have provided the following summary and analysis to assist aviation safety organizations and other interested groups in disseminating information that has general application to all types of aircraft.

Fokker Flight Simulation Report

To assist my investigators, Fokker agreed to make available its Fokker 100 fixed-base engineering flight simulator to conduct flight tests on the F-28 Mk1000. The Fokker 100 aircraft is a new and larger derivative of the F-28 series aircraft, and, although somewhat similar in appearance to the F-28, it has appreciable aerodynamic differences. The Fokker 100 engineering flight simulator was capable of being adjusted to approximate the flight characteristics of the F-28 Mk1000 aircraft, and it was possible to simulate slush on the runway to provide rolling resistance contamination. The simulator was also capable of simulating performance degradation caused by wing leading-edge ice. Fokker, by calculation, was able to equate flight performance degradation from wing leading-edge ice with roughness caused by wing surface contamination. Aerodynamic testing demonstrated that 1 inch of leading-edge "horned" ice created approximately the same 30 per cent loss of lift as did the roughness of 1–2 mm diameter particles distributed one per square cm of wing surface.

To investigate the effect of runway slush and wing contamination, Fokker adjusted the Fokker 100 engineering simulator to enable it to perform as C-FONF should have performed during its takeoff at Dryden if the runway had been bare and dry and the aircraft wings clean. A 6000-foot airport runway was selected with an elevation of 1500 feet asl and 0° slope to approximate Dryden airport conditions. Takeoffs were

conducted on a dry runway and on a runway covered with equivalent water depth (EWD) of up to 0.5 inches.[7] Most takeoffs were conducted with runway slush of 0.15 inches EWD to approximate the average EWD that was estimated, based on judgements, reports, and simulator studies, to have been on runway 29 at Dryden airport. Takeoffs were conducted with wing-ice equivalent on the wing from 0, representing a clean wing, to 1.00, representing contamination in an amount equal to one 1–2 mm diameter particles per square cm of the wing surface. A total of 30 takeoffs using 18° of flap were flown by the performance subgroup on June 7 and 8, 1989, and Fokker Aircraft flew a further 12 takeoffs on August 1, 1989, using 25° of flap. Normal takeoff profiles were varied by lifting the nose wheel out of the slush during the takeoff roll, rotating the aircraft more slowly at V_R, and failing the critical engine at V_1.

The details of the simulation testing, findings, and observations are summarized on pages 3 through 9 and in figures 35, 36, and 37 (reproduced below) of the "Flight Simulation" report. Fokker's observations were as follows:

1 The takeoff distance of an F-28 Mk1000 without runway slush or wing contamination was closely approximated by the F-100 simulator through weight and thrust selections.
2 The increase in takeoff distance of an F-28 Mk1000 with runway slush but without wing contamination was closely approximated by the F-100 simulator.
3 The effect of ice on the wing is considerable. Above a certain wing-contamination level, aircraft performance loss is so large that the aircraft cannot climb out of ground effect using normal handling techniques.
4 Engine failure at V_1 is catastrophic when combined with slush on the runway and some contamination on the aircraft wing.
5 There is greater sensitivity to wing contamination at higher altitudes owing to decreased aircraft performance.

The above-noted figures of the "Flight Simulation" report graphically describe the increase in both takeoff distance (TOD) and takeoff run (TOR) required as a result of contamination on the wing and slush on the runway.[8] They are reproduced below as figures 12-5, 12-6, and 12-7.

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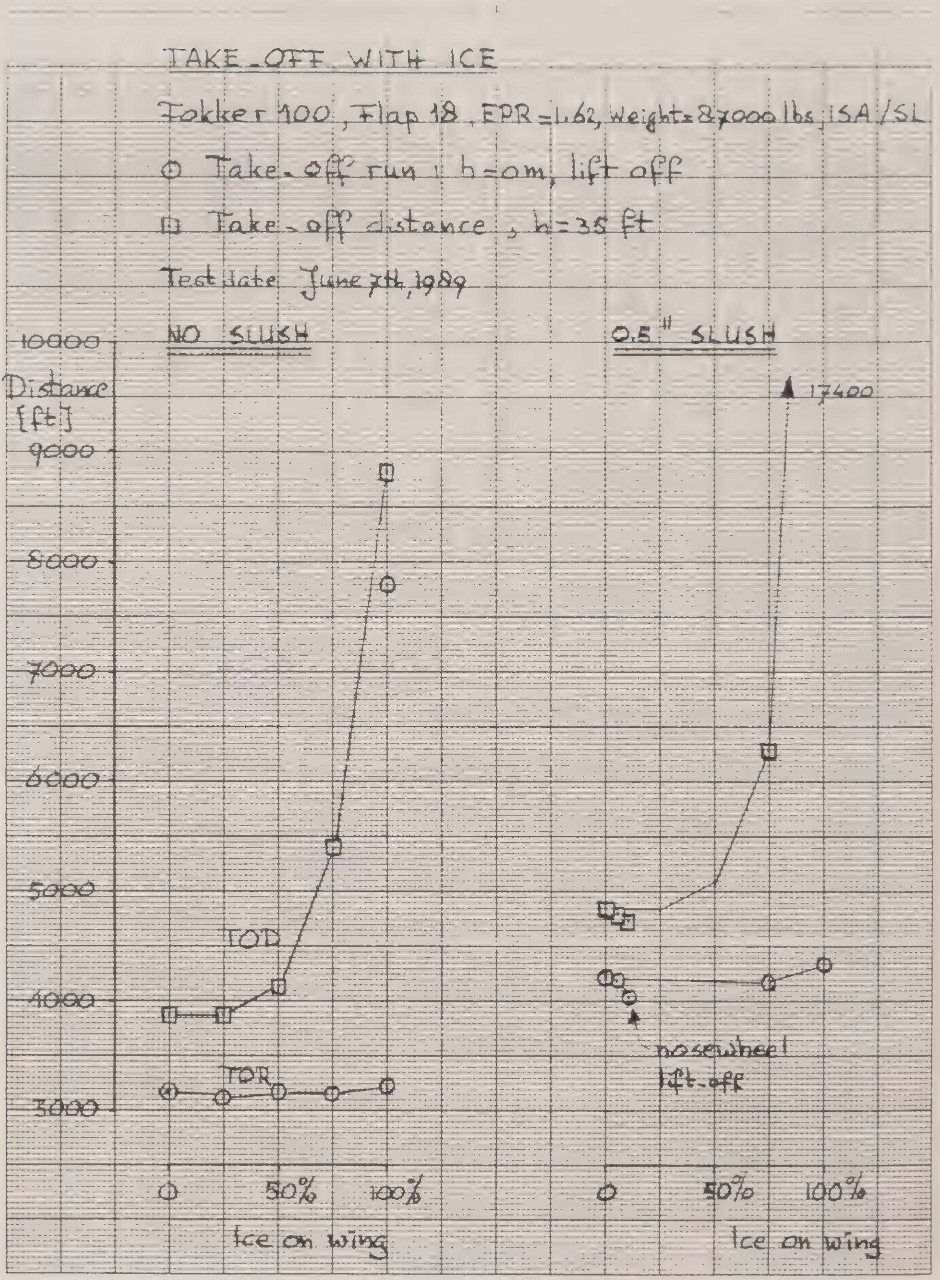
[7] Equivalent water depth (EWD), in general terms, is the depth of free-standing water that is equivalent to the depth of given precipitation. (Precipitation covers the whole range of densities, from that of dry snow, to slush, to free-standing water.)

[8] Takeoff distance (TOD) is the horizontal distance from the start of the takeoff until the aircraft reaches a screen height of 35 feet. Takeoff run (TOR) is the horizontal distance from the start of the takeoff to the point at which the main landing gear of the aircraft lifts off the runway.

Figure 12-5 Fokker 100 Simulation of Takeoff with Ice, Flaps 18°



Source: Exhibit 544, figure 35

Figure 12-5 describes the Fokker 100 simulator with 18° of flap at sea level taking off with power and weight equal to full power on an F-28 at 63,500 pounds. By loading up the wing with contamination from 0, representing a clean wing, to 1.00, representing contamination in an amount equal to 1–2 mm diameter particles per square cm of wing surface, but with no runway slush, the takeoff run of the F-28 ranged between 3100 and 3250 feet. However, as contamination on the wing increased from 0.5 to 1.00, the takeoff distance increased from approximately 4150 to 8800 feet.

During takeoffs with 0.5 inches of runway slush, the takeoff run ranged between 4200 and 4350 feet, representing an increased takeoff run of approximately 1000 feet owing to slush. Raising the nose wheel out of the slush decreased the takeoff run marginally.

With 0.5 inches of runway slush and a wing-contamination range of 0.5 to 1.00, the takeoff distance increased dramatically. With 0.5 inches of runway slush and 0.5 wing contamination, the takeoff distance was 5100 feet. Fokker estimated that by increasing the wing-contamination level to 1.00, representing a wing completely contaminated with 1–2 mm particles on each square cm of the wing, the takeoff distance of the F-28 would be 17,400 feet. In other words, the aircraft was unable to climb out of ground effect.

Figure 12-6 provides information that reflects the runway slush condition assumed to exist at Dryden at the time C-FONF crashed. All takeoffs were conducted with runway slush of 0.15 inches equivalent water depth (EWD) and flaps set at 18°. Takeoff runs increased from 4400 to 6000 feet and takeoff distances increased from 5100 to 7900 feet as wing contamination increased from 0 to 0.8.

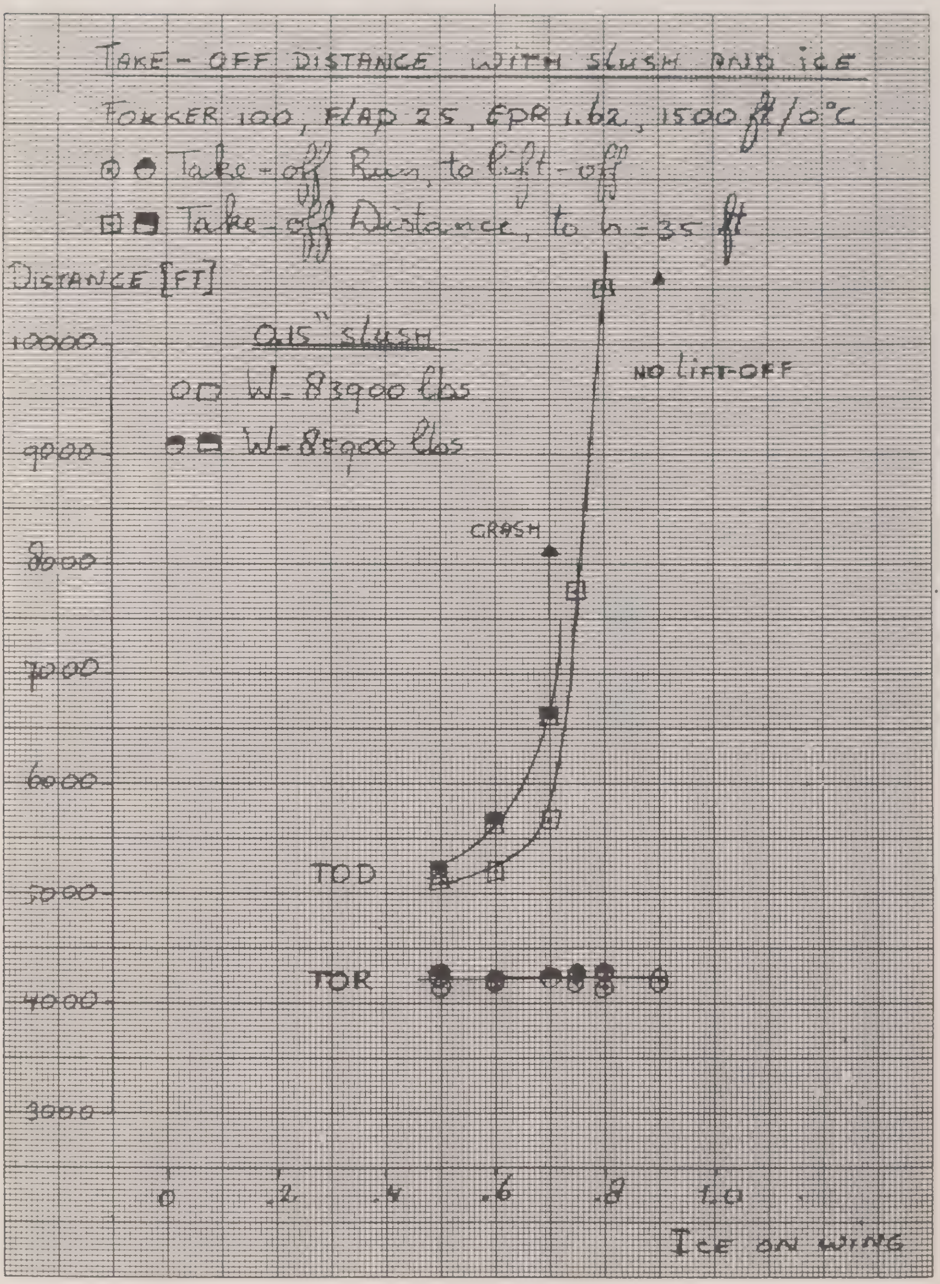
It is assumed that C-FONF had an equivalent wing-contamination level of at least 0.8 during its takeoff. With wing contamination in excess of 0.8, and slush depth of 0.15 inches EWD, both the takeoff run (TOR) and the takeoff distance (TOD) are greater than the runway length available at Dryden.

Figure 12-7 demonstrates the estimated takeoff performance of C-FONF utilizing 25° of flap in 0.15 inches of EWD of slush. Although the takeoff run performance is better at a 25° flap setting than it is at 18°, with higher amounts of wing contamination the takeoff distance required continues to be high or even increases, and at 0.8 wing-contamination level the aircraft failed to lift off.

In all cases where an engine failure occurred at V_1, with moderate wing contamination, the aircraft was unable to fly away, and in each instance it crashed.

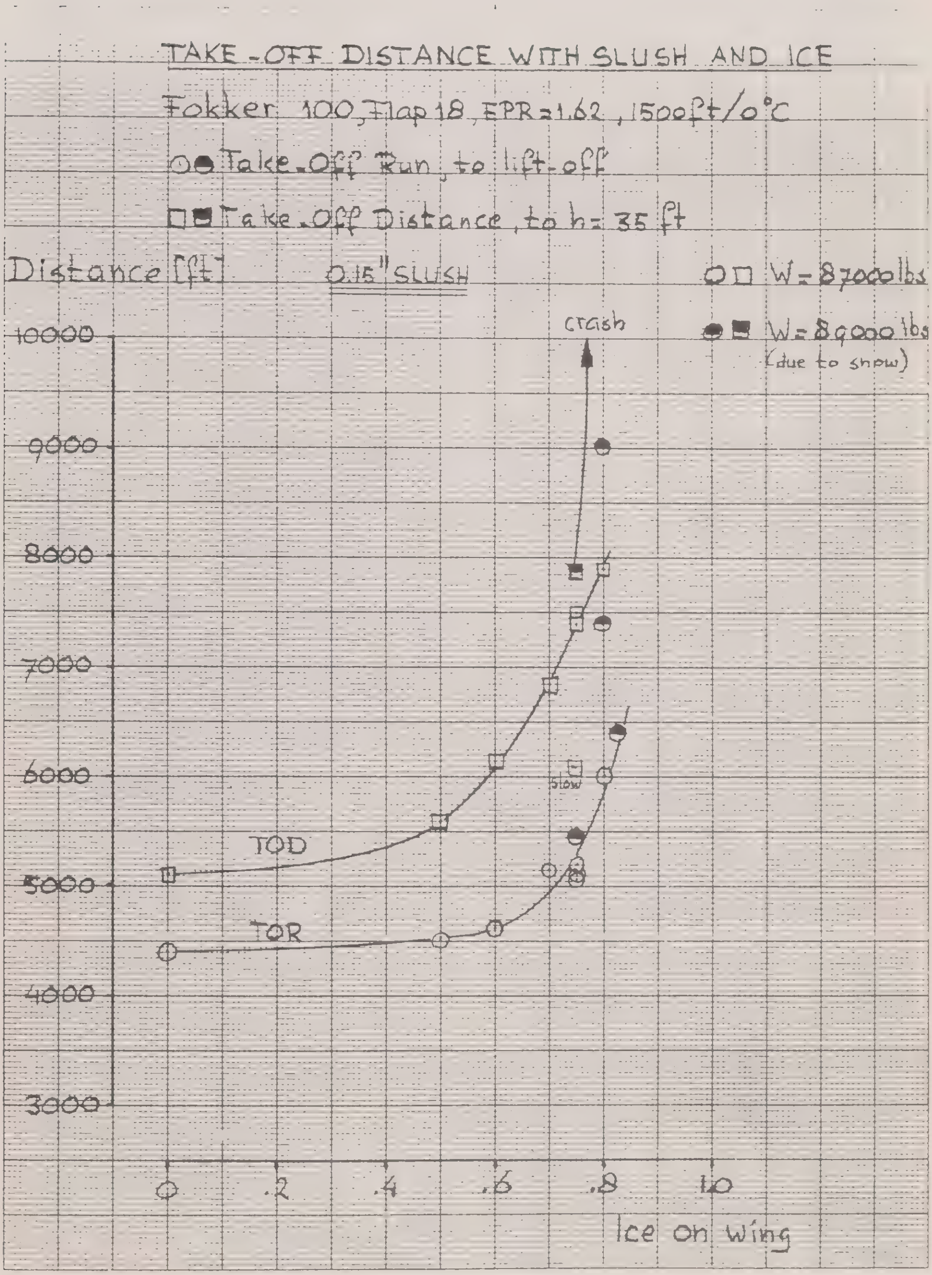
It was clearly revealed from the tests that by rotating the aircraft at a slower rate at V_R, the takeoff run increases slightly but the takeoff distance actually decreases. It was noted that, under similar conditions

Figure 12-6 Fokker 100 Simulation of Takeoff with Slush and Ice, Flaps 18°



Source: Exhibit 544, figure 36

Figure 12-7 Fokker 100 Simulation of Takeoff with Slush and Ice, Flaps 25°



Source: Exhibit 544, figure 37

of slush and wing contamination, with a slow rotation the takeoff run increased by 10 m (32.8 feet) from 1545 m (5070 feet) to 1555 m (5100 feet) while the takeoff distance actually decreased 435 m (1427 feet) from 2285 m (7495 feet) to 1850 m (6070 feet).

Mr van Hengst had the following to say regarding the use of a slow rotation technique when the aircraft wings are contaminated:

> Q. So if there is contamination and the pilot suspects contamination on the wing, there is a real advantage to him to rotate slower?
> A. Yeah. In fact, this is the same what is already said in our information we released to customers, and what is shown in the Boeing Airliner, what we just discussed yesterday.
> Q. So you have advised, in the flight manuals, and advised customers of that fact, that slower rotation may in fact save a situation that otherwise might result in a crash?
> A. Well, we advise that you increase your margin, but our advice is first to clean the wing.
>
> (Transcript, vol. 71, p. 35)

When asked what general conclusions were reached by Fokker Aircraft as a result of the simulator test flights, Mr van Hengst responded as follows:

> A. Well, that it was impossible to try to take off an aircraft with contamination on the wing. And you should always remember that this simulation test shows distributed contamination of 1 to 2 millimetre. That is the equivalent, so if the distributed roughness was worse than the picks, what you have seen on that grey plate, it should be worser and it can be worser. That's one.
>
> The second is for the engineering and technical pilots, it's very educative to do such studies. We did it with our test pilot in 1969, but you never must draw the conclusion that there is a chance to take off, because in actual practice, nature is never a thing what you can interpolate it linearly from zero to 100 per cent.
>
> (Transcript, vol. 71, pp. 36–37)

Flight Dynamics Report

The following pages provide a summary of the performance subgroup's "Flight Dynamics" report and of the evidence given before this Inquiry by the authors.

The function of the subgroup was to investigate both the takeoff performance of the F-28 and the effects of environmental conditions at the time of the accident on the aircraft's performance. The subgroup utilized F-28 performance data supplied by Fokker and developed

computer programs to model mathematically the aerodynamic characteristics of the F-28 with and without contamination. Thereafter, the subgroup validated and correlated the results and offered conclusions as to the engineering reasons for the flight path observed at Dryden. The objective of the computer-simulation work was to develop a range of possible flight path scenarios similar to the one flown by C-FONF and then determine a range of conditions that could have caused C-FONF's flight path.

The purpose of the simulation and modelling was to determine, in the absence of recorder data, possible causes of the reported flight path of C-FONF. The modelling also allowed independent confirmation of the Fokker 100 engineering flight simulator study results, necessary because the study was carried out on a somewhat different aircraft. The modelling further allowed the exploration of other relevant areas such as engine-out performance and non-standard handling techniques. The aerodynamic analysis described in the "Flight Dynamics" report was carried out to support the simulation efforts and to provide enhanced background for this Commission's investigation.

The authors utilized available information with respect to C-FONF on March 10, 1989, including witness statements regarding aircraft performance as well as contamination on the aircraft wings and on the runway. The authors' analysis of available information suggested a sequence of events approximating the following, which was used by them for modelling purposes and was termed the "Dryden scenario":

> The aircraft, in an 18 degree flap configuration, commenced its take-off run from a normal position on the runway, achieved rotation speed somewhat further down than was normal and commenced a rotation. During the initial rotation the machine either became briefly airborne, or simply extended the oleos, and then settled back onto the runway, reducing its body angle somewhat. A second rotation very close to the end of the runway resulted in the aircraft becoming airborne but maintaining a very low altitude until striking the trees. Subsequent technical investigation has shown that at some time during the take-off attempt the wing flaps were extended from 18 to 25 degrees and that at the time of impact the undercarriage was in transit (neither fully down nor fully up).
>
> (Exhibit 526, p. 67)

The modelling task was simplified because, since the aircraft did not gain significant altitude, consideration of the vertical dimension could be eliminated. The subgroup accounted for the change in flap setting after the first rotation. The small change in overall drag coefficient resulting from the landing gear was not significant to the relevant portion of the takeoff performance.

Commission investigators were advised, and some Air Ontario pilots testified, that the paint on the leading edges and surfaces of the wings of one or both of Air Ontario's F-28s was cracked and deteriorated. The original paint on the leading edges and wings of an F-28 is 0.016 inches thick and consists of three or four layers. Although there was some evidence before me to indicate that the paint on the leading edges of the wings of C-FONF was in a deteriorated condition, the authors of the "Flight Dynamics" report and Fokker aerodynamicists, in particular Mr van Hengst, were of the view that the effect of the cracked paint on the maximum lift coefficient and stalling angle of attack is not significant. It was not determined to what degree, if any, cracked or deteriorated paint contributes to the adhesion of contamination to a wing.

In conducting their analysis, the authors of the "Flight Dynamics" report made the following assumptions:

1 The powerplants generated normal thrust throughout the takeoff attempt (although single powerplant failure was considered for completeness).
2 There were no structural failures prior to impact.
3 There was no failure of the brakes or tires such as to cause the ground roll to be extended.
4 There were no flight control system failures.
5 There was no interference in the flight control system from any source.
6 The flight crew handled the aircraft with normal handling techniques.
7 There were no system or instrument failures such that the flight crew was unable to fly the aircraft with the precision required for instrument flight.
8 There were no adverse wind conditions that would have affected the aircraft's performance.

All evidence before me, as detailed in this my Final Report, confirms either that the authors' assumptions were correct or indicates that there was no evidence found during the investigation or revealed in testimony to suggest that the assumptions were incorrect.

Witness evidence indicates that 18° of flap was selected on C-FONF before the takeoff run commenced. Investigation determined, however, that the flaps were positioned at approximately 25° when the aircraft crashed, suggesting that a selection from 18° to 25° was made by the flight crew some time after the takeoff roll commenced. It is probable that the selection of 25° of flap was made after the first liftoff, when it may have become apparent to the flight crew that a successful takeoff was in doubt. Performance analysis by Fokker and by the subgroup authors indicates that, with contamination on the wings, the use of 25°

of flap will not improve aircraft performance after liftoff. It is the view of both Mr Wagner and Mr van Hengst that extending the flaps beyond the position selected and used for the takeoff should not be considered in conditions of wing contamination; the greater flap angle would have a detrimental effect on the aircraft performance should the aircraft actually become airborne.

Aerodynamics

The aerodynamics section of the "Flight Dynamics" report, authored by Mr Richard Wickens, surveys the aerodynamics principles relevant to the Fokker F-28 during the ground-roll and initial climb phase. Mr Wickens also discusses the degree to which surface roughness, such as ice contamination, affects this low-speed portion of the aircraft's flight envelope. Fokker supplied aerodynamic data to the performance subgroup. Materials provided included the results of a wind tunnel test at the Nationaal Lucht-en Ruimtevaartlaboratorium (NLR), the Dutch national aerospace laboratory; a description of the aerodynamics of wing stall; flight test experience with the aircraft; airfoil pressure distribution at a variety of angles of attack; boundary layer data for an F-28 airfoil section; and Fokker's data base from which the F-28 simulator model was created.

The following is a summary of the findings and conclusions of Mr Wickens, as noted in the aerodynamics section of the "Flight Dynamics" report.

The F-28 wing section is designed for a cruise Mach number of 0.75 and a high maximum lift coefficient at low speeds. (Mach 1.0 is the speed of sound.) A generous wing nose radius minimizes the likelihood of separation under high lift conditions and promotes stall from the trailing edge. There is a stall fence on the forward midsection of the wing. Stalling of the basic smooth wing is from the trailing edge. The stall then spreads outwards from the leading-edge fence location in a fan-shaped manner towards the wing-tip and wing-root regions. These regions stall last, and, since the ailerons are near the wing tip, lateral control is possible after other sections of the wing are in a stalled condition. As well, because of the position of the fences, air flow into the engines remains smooth to high angles of attack. In ground effect, with the main wheels on the ground, stalling occurs at an angle of attack some 4° lower than flight in free air, but only the inner portion of the wing stalls. Maximum coefficient of lift (C_{LMAX}) is unchanged.

During wind tunnel tests conducted by Fokker Aircraft, artificial roughness on the upper surface of the wing of an F-28 aircraft model caused a premature stall during which time boundary layer separation could have occurred all along the leading edge. The roughness corresponded to an element size of about 1–2 mm on the full-scale F-28 wing,

while the distribution corresponded to approximately one element per square cm on the same wing. With the flaps set to 30° on the model, the wing stalled at an angle of attack 7° lower than for the clean wing. Compared with the clean wing, the model showed 33 per cent loss of maximum lift coefficient.

Research on model wing sections at Reynolds Numbers[9] ranging from 100,000 to 10,000,000 showed that roughness not only increases drag below the stall but also increases the likelihood of a premature stall, particularly if the wing nose is roughened. Since the Reynolds Number increases towards the values experienced by the F-28 wing during takeoff (greater than 10,000,000), the loss of maximum lift can be as high as 50 per cent compared with a clean surface.

In some cases, the airfoil is sensitive to the size of the roughness elements, the loss of maximum lift being less for very small roughness heights. Most airfoil sections, however, respond to roughness of any scale by stalling prematurely and incurring the maximum loss of lift. Removal of roughness on the nose and over the first 15 per cent of the chord restores the airfoil to a surface close to its original "clean" characteristics.

Dynamic Simulations

The dynamic simulations section of the "Flight Dynamics" report, authored by Mr Gary Wagner, presents a description of and commentary on the results of the simulation flights carried out by the performance subgroup. Mr Wagner discusses the Fokker "Flight Simulation" report and provides background to it. He discusses the various modelling and flying techniques, both conventional and non-standard, utilized during the subgroup's sessions and summarizes the simulation experience. The following is a summary of the material dealing with the simulation sessions.

---

[9] Reynolds Numbers, a measure of the scale effect, enable one to correct for the difference between doing a test under model conditions at small scale and extrapolate the data to full-scale values. It also determines when a laminar flow makes a transition to turbulent flow. Physically, it is the ratio of the inertia forces to the viscous forces in any flow. Inertia forces are the stream lines and flow outside the boundary layer. Viscous forces are the stream lines and flow inside the boundary layer. Reynolds Numbers are dimensionless. In the case of the F-28, and based on its wing mean aerodynamic chord, they range between approximately 15,000,000 at takeoff speed and 30,000,000 at cruising speed. Turbulence over a flat plate surface normally commences when Reynolds Numbers reach approximately 1,000,000. Reynolds Numbers are used in classical research of boundary layer and Reynolds Numbers behaviour on wings.

(Based on evidence of Mr Richard Wickens. Transcript, vol. 69, pp. 66–68)

Dynamic simulations were those tests and experiments conducted in the Fokker 100 fixed-base engineering simulator. Three series of dynamic simulation sessions were flown using various wing- and runway-contaminant levels. Two series of simulations were flown on June 7 and June 8, 1989, by Mr Wagner and monitored by Mr Murray Morgan, and the third series was flown by Mr Jan Hofstra, a Fokker Aircraft test pilot, on August 1, 1989. The data from the simulations were plotted in the Fokker report to present pictorially and numerically the flight profiles and changes that would be experienced in aircraft performance.

Mr Wagner stated in his overview:

> A fundamental assumption made during the simulation exercise was that the pilots of the accident aircraft would have believed that their aircraft was flyable and would, therefore, have employed normal handling techniques. Therefore, for "Dryden" simulations no special procedures or techniques were allowed which would have provided a better flight profile due to the simulator pilots' a priori knowledge of the external conditions being applied. Ad hoc experiments with off nominal techniques left no doubt that handling technique greatly affects the resulting flight profile in the presence of contamination. This observation was later confirmed by the off-line numerical modelling.
>
> (Exhibit 526, p. 62)

Dynamic Simulations: Modelling and Flying Techniques

Runway Contamination The slush model depth was varied from 0 to 0.45 inches to determine the level of slush contaminant required to extend the takeoff run to the distance reported by the witnesses at Dryden (that is, approximately 500 feet in excess of the normal takeoff run). It was determined that a slush depth of 0.15 inches resulted in this increase. Mr Wagner noted that, because of reduction in the maximum coefficient in lift resulting from wing contamination, the aircraft must be rotated to a higher than normal pitch attitude in order to effect liftoff; this process takes additional time and results in a longer takeoff roll. The additional component was considered in the simulation.

For contaminated runway takeoffs, normal control wheel inputs were used in all but a few runs, where the nose was raised 2–3° at about 80 knots to get the nose wheel out of the slush (the specified procedure in the Fokker F-28 Flight Handbook). It was found that raising the nose wheel decreased the aircraft ground roll by approximately 100 feet.

Wing Contamination The wing contaminant was modelled by using the Fokker roughness simulation for the entire wing. The contaminant factor could be varied between 0 and 1.00. This factor is not equivalent to contaminant depth, although it is labelled as such on the plots provided

in the Fokker report. Wing contaminants with different characteristics, even of identical depth, will result in very different performances. For example, a thin layer of a rough contaminant can result in a far greater performance loss than a thick layer of a smooth contaminant that follows the wing contour. In any consideration of wing performance, form and position of a wing contaminant are much more important factors than is thickness.

During the dynamic tests, it was determined by the authors that, at wing-contaminant levels greater than approximately 0.8, the aircraft would not fly off the runway at the aircraft speeds and conditions that generally matched those of C-FONF. Selection of contaminant levels ranging from 0.5 to 0.8 did, however, result in flight profiles that generally matched the profile of C-FONF. The runs that most closely matched the flight profile described by witnesses at Dryden were achieved with a slush depth of 0.15 inches and a wing-contaminant level of approximately 0.8.

For contaminated wing takeoffs, although normal control wheel rotation forces were used, the resultant rotation rate was slightly slower than with the clean wing model. The reason for the slower rotation rate was that the wing contamination had the effect of increasing the nose-down pitching moment of the wing; therefore, with normal forces being applied to the control wheel, the nose-up moment caused by the elevator had less rotational effect on the aircraft.

As the contaminant levels were increased, numerous takeoff runs were flown where the stick-shaker actuated immediately on or just after liftoff. This effect occurred because of the significantly greater angles of attack achieved in these cases. It was judged by the investigators that normal pilot technique would be to attempt to reduce the angle of attack to stop the stick-shaker. Nose-down control-wheel inputs were made accordingly, attempting to maintain an aircraft attitude right at the edge of stick-shaker activation. The reasoning here was that most pilots, in view of current training with respect to wind shear escape manoeuvres and ground school training, would expect to achieve close to maximum available lift at the point of stick-shaker activation.

In pointing out that the wing was stalling prior to stick-shaker activation, Mr Wagner in the "Flight Dynamics" report stated as follows:

> It should be noted that in cases of significant wing contamination, the wing can be well beyond the stalling angle of attack by the time the stick shaker activates. In essence, the stick shaker is responding to the normally expected maximum angle of attack of the clean wing. The stall warning system is not actually measuring stall and flow separation from the wing. Rather, it infers the onset of stall from the

> known performance of the wing and is programmed to activate at a fixed geometric angle of attack based on that knowledge.
>
> (Exhibit 526, p. 64)

Of significance is the fact that, with any amount of wing contamination, the aircraft wing may stall before the angle of attack required to activate the stick-shaker is reached.

Engine Failure on Takeoff A few takeoffs were attempted by Mr Wagner during which an engine was failed at V_R. All engine failures were complete (that is, no attempt was made to fly the simulator with partial engine failure). Regardless of the contaminant level on the aircraft, directional control was not a problem after the engine failed. Normal and appropriate control inputs were used to attempt to maintain proper speeds and direction. The climb-out characteristics of the aircraft were conventional with the engine failure, except that only a limited wing-contaminant load could be carried.

The wing-contaminant level at which the aircraft was able to lift off and climb was significantly reduced. Successful takeoffs were accomplished with wing contamination of less than 0.5, although that level provided minimal performance. Because the relationship between wing-contaminant levels and contaminant thickness is highly non-linear, the authors in this section of the "Flight Dynamics" report caution that the result cannot be interpreted to mean an aircraft is able to carry half the contaminant load with an engine failure. The report states that "it was clear that the reduced thrust at rotation severely reduced the available performance margin and thus limited the aircraft's capability to carry any contaminant through a successful takeoff" (Exhibit 526, p. 61).

Summary of Simulation Experience The following is a summary of the authors' observations and findings as a result of their flight-simulation experience and analysis:

- The effect of increasing the slush depth was limited, in general terms, to increasing the takeoff run. Additional effects became evident regarding the ability of the aircraft to accelerate after rotation with the wing significantly contaminated.
- The effect of wing contamination was to degrade the performance of the wing, the degree of degradation being a non-linear function of the contaminant level. As the wing-contaminant level increased from 0, the aircraft's climb performance was immediately reduced.
- At moderate levels of wing contaminant, the stick-shaker actuated shortly after liftoff, and the flight profile after that point reflected the pilot's attempt to keep the aircraft at the edge of the stick-shaker, being 13° angle of attack for the simulator. For

a contaminated wing, that angle of attack was already post-stall in most cases. Climbing out of ground effect became impossible in many instances.

- At critical levels of wing contaminant, between 0.75 and 0.825, the aircraft was able to lift off and sometimes fly. However, as the aircraft climbed out of ground effect, the performance loss resulted in the aircraft descending and touching down or crashing off the end of the runway.
- As the contaminant level increased, the liftoff pitch attitude and airspeed had to be increased to provide adequate lift to lift off. Since increasing levels of wing contaminant decreased the stalling angle of attack, liftoff occurred closer to and then beyond the true stalling angle of attack. Eventually, either liftoff occurred post-stall or the aircraft stalled shortly after liftoff as it climbed out of ground effect. Successful flight with the wing contaminated at levels between 0.7 and 0.825 was effectively impossible using normal techniques. The profiles resulting from flight at these wing-contaminant levels were, in general terms, representative of the flight profile of C-FONF resulting in the Dryden accident.
- In cases where an engine was failed, the aircraft was not flyable with even moderate levels of wing contaminant. The high angles of attack required to generate adequate lift with the contaminated wing produced drag levels so great that the thrust of one powerplant was inadequate to allow the aircraft to accelerate. Post-stall drag was also extremely high. The only way to get the aircraft to fly with the wing contaminant is to have sufficient thrust to accelerate to a sufficiently high airspeed. Thrust with one engine operating is inadequate to provide that acceleration.

(Based on Exhibit 526, pp. 64–65)

Non–Standard Handling Techniques Non–standard handling techniques were explored by the authors in an effort to determine whether the aircraft could overcome performance degradation resulting from contaminated wings. Successful flight was achieved in certain cases that might otherwise have resulted in either no takeoff or takeoff and a subsequent crash. The authors could not, however, predict precisely when these flights would succeed; when non–standard procedures were used, successful takeoffs with wing contaminant at levels between 0.7 and 0.825 were irregular and not guaranteed. Nevertheless, it was determined that the following non–standard handling techniques did allow for more successful takeoffs:

- Selection of rotation speed. A pilot who applied a speed increment above V_1 prior to rotation would have a higher probability of a successful takeoff. The converse is also true.

- Use of a lower rotation rate. A pilot who used a slower rotation rate would have a higher probability of a successful takeoff.
- Use of a partial rotation (as opposed to continued rotation until liftoff). A pilot who rotated the aircraft to usual liftoff attitude and held it there rather than rotating further would have a higher probability of a successful takeoff.

The above recommended techniques are also contained in the Fokker F-28 Flight Handbook. Fokker recommends these techniques where it is not completely certain that the wings and tail are clear of ice or snow.

The authors emphasize in their report that use of non–standard handling techniques is not intended to assist or condone operation of aircraft carrying wing contaminant. There are many other tradeoff factors that are balanced out in any takeoff. The authors state that the foregoing non–standard handling techniques may degrade such tradeoffs.

These non–standard handling techniques may, however, assist a flight crew finding themselves, for some reason, in a takeoff situation where there is no possibility for a safe rejected takeoff and the aircraft is not performing as expected. This situation could be the result of a number of factors, such as wing contamination, aircraft overloading, incorrect flap selection, or incorrect speed selection. The situation could also occur on a rejected landing and go-around if, on approach, the aircraft is contaminated with ice.

Once an aircraft has reached rotation speed (V_R) there is normally little or no opportunity to reject the takeoff. When asked whether a crew experiencing the effects of contamination at rotation or immediately after liftoff should continue or reject the takeoff, Mr Wagner stated the following:

> A. I would say that my best judgement would be that, once you've rotated and barely got a little bit airborne, it would be highly unlikely for a man to put his efforts into aborting the takeoff rather than putting his efforts into finding a way to try and make that takeoff successful. That would be my best judgement, sir.
>
> (Transcript, vol. 73, pp. 146–47)

On the basis of the evidence I have heard, I am firmly convinced that pilots should be made more aware of the inherent dangers of wing contamination. It is vitally important for a pilot to understand how wing contamination changes the aerodynamic characteristics of an aircraft, and to understand how the application of certain techniques, as described above by Mr Wagner, may allow a pilot to deal with an abnormal takeoff situation. It is incumbent on all pilots and on their respective

organizations to ensure that this training is accomplished. Without prescribing how the necessary training be accomplished, I would state that it is possible flight simulators may be useful in this endeavour. It must be stressed, in the strongest terms possible, that neither the performance subgroup nor this Commission advocates the use of non–standard handling techniques to operate aircraft in adverse weather conditions as an alternative to the proper preparation of the aircraft for flight.

Mathematical Modelling and Modelling Validation

Mr Murray Morgan is the author of the mathematical modelling and modelling validation sections of the "Flight Dynamics" report. The following is a summary of the methods used for and the results of the mathematical analysis and validation of the flight dynamics of the attempted takeoff of C-FONF.

A computer model was developed to allow investigation of the effects of aircraft and runway contaminants on the takeoff performance of the aircraft. There is no "man in the loop" (pilot) in a computer model, thus removing one of the variables from the equations. The model was therefore able to reflect more accurately the effects of aircraft and runway contamination. Initially, two independent off-line computer models of the F-28 were developed simultaneously by Mr Morgan and Mr Wagner. The outputs from each model were periodically compared, and, where differences were found, the source was isolated and corrected. Once the programs were both operating and producing comparable results, the more powerful computer used by Mr Morgan at NAE was employed for most of the investigation and production of results.

There was no attempt made to model contamination of the horizontal stabilizer. The reasoning was twofold: first, as there was sufficient power (lift) on the tail to rotate the aircraft during the takeoff, the contamination on the horizontal stabilizer was not a factor during rotation; secondly, the angle of attack of the tail reduces as the aircraft accelerates after becoming airborne, thereby further decreasing the effect of any contamination.

The aerodynamic and performance models were based on two sources of data: the F-28 simulation data base provided by Fokker; and the Fokker wind tunnel study of the contamination model of the F-28 lift and drag characteristics when the flying surfaces were contaminated with artificial roughness. To develop a functioning simulation that included "man in the loop" control of the aircraft, the engineering and pilot judgement of Mr Morgan and Mr Wagner also played an important role. With the performance and contamination model of Fokker and control response algorithms developed by the authors, a functioning off-

line simulation for the F-28 was developed. To verify the accuracy of the computer simulation, use was made of flight data recorder (FDR) data from 21 previous takeoffs by C-FONF. A month prior to the Dryden accident, C-FONF was involved in a minor accident, when a wheel failed on a landing. Investigation of this event necessitated FDR tape removal; hence, data from this tape were available to the authors.

Model-Run Matrix Once the modelling had been completed and validated, a matrix of cases was empirically determined and run. For all cases, the baseline configuration was an aircraft weight of 63,500 pounds, full-rated thrust, 18° of flap, and a V_R of 122.5 knots. The nominal rotation was an initial pitch rate of 3° per second towards a target attitude of 10° followed by a further rotation at 1° per second to 13° of pitch attitude after liftoff. This is the procedure preferred by Fokker Aircraft. Thereafter, three parameters of prime interest were varied: the depth of slush, the proportion of wing contamination, and the selection of V_R. These runs were completed using the nominal rotation technique, described above, together with the profile referred to above as the "Dryden scenario." Nominal (3° per second) and reduced (2° per second) rotation rates were used for the initial rotation. The sets of conditions tested were:

a. Slush Depth. 0, 0.1, 0.2, 0.3, and 0.4 inches.
b. Contaminant Ratio. 0 and .50 to 1.00 in steps of 0.01. (Zero to 1.00 represents 0 per cent to 100 per cent contaminant. When this resolution produced ambiguous results, boundaries were defined by making special runs at finer resolution.)
c. Rotate Speeds. 117.5 knots, 122.5 knots (nominal), and 127.5 knots.
d. Rotation Rates. 3° and 2° per second.

(Based on Exhibit 526, p. 73)

Presentation of Results Plots of the test runs are included in the "Flight Dynamics" report of (technical appendix 4, pages 76–85). These plots show that the presence of slush on the runway significantly increased the distance required to reach V_R, while wing contamination had little effect on this distance. However, as the level of wing contamination increased, the distance to liftoff increased quite rapidly, owing to the marked increase in drag produced by the contaminated wing at high angles of attack following rotation. This characteristic represents a situation in which the full extent of performance loss may not be apparent to the flight crew until the aircraft is rotated. Prior to this point, the reduction in acceleration is little more than what could be attributed to a slush layer. Figure 5 on page 76 of the "Flight Dynamics" report shows the reasons for this effect. As the level of wing contamina-

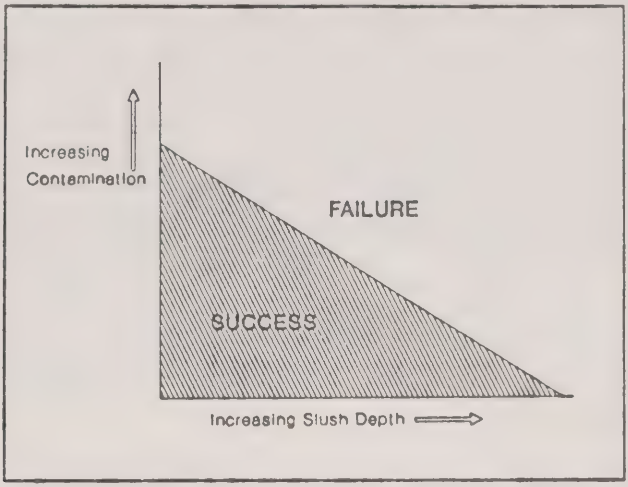
tion increased, even in the absence of slush, the distance between V_R and the liftoff point increased only slowly, until a dramatic "knee" was reached numerically at just over 0.6 contamination ratio. This is coincident with the aircraft being at or beyond the coefficient of maximum lift (C_{LMAX}) for the contaminated wing at its rotation angle of 10° and having to generate the necessary lift by increasing speed rather than increasing the coefficient of lift (C_L).

The drag rise, caused by the contamination once the aircraft was rotated, resulted in low acceleration rates. This in turn meant that excessive distance had to be used by the aircraft to attain enough speed to generate sufficient lift. Another effect was the increase in Theta required at liftoff as the level of contaminant increased. (Theta, or body angle, is the angle between the aircraft and the horizontal.) Moderate increases in Theta compensated for the reduction in the coefficient of lift due to the contaminant up to a contamination ratio of approximately 0.58. At that point the rate of increase in Theta, with respect to the level of contaminant, steepened markedly because of the reduced lifting capability of the wing.

The two "various boundary" plots in the "Flight Dynamics" report (p. 77) represent the crux of the performance investigation. They show that it is possible to define two boundary conditions, in terms of combinations of slush depth and wing-contamination factor, that can lead to catastrophic results during attempted takeoffs. A boundary condition here means "a continuous relationship between level of contamination and runway slush depth which represents the dividing line" between a successful or unsuccessful takeoff (pp. 73–74). This boundary relationship, which is illustrated in the "Flight Dynamics" report, is reproduced below as figure 12-8. The "various boundary" plots (figures 6 and 7 in the "Flight Dynamics" report) can be interpreted according to figure 12-8, below.

Figures 8a–10b of the "Flight Dynamics" report illustrate in detail the various test runs. A review of the figures reveals that there are well-defined boundaries of slush depth and contamination level that either allow or prevent the aircraft from flying successfully. For example, with a rotation speed (V_R) of 122.5 knots, a slush depth of 0.25 inches, and a wing-contamination level of 0.65, the aircraft flies away. At 0.68 wing contamination, the aircraft gets airborne, but, 500 feet beyond the end of the runway, it is only at 10 feet. At 0.69 contamination, the aircraft returns to the runway and runs off the end. In another example, with a rotation speed of 127.5 knots, a slush depth of 0.10 inches, and a wing-contamination level of 0.823, the aircraft flies away despite two bursts of stick-shaker. At 0.824 wing contamination, the aircraft height never exceeds 5 feet, and it eventually returns to the surface 1100 feet beyond

Figure 12-8 A Boundary Condition Plot for Successful Takeoff



Source: Exhibit 526, figure 3

the end of the runway. The figures also demonstrate that pilot technique can have a marked effect on the success or failure of a takeoff.

The implication of the results presented in this section of the "Flight Dynamics" report, especially the two sets of boundary conditions, is that there "exists a combination of values of slush depth and wing contamination which can cause aircraft trajectories of the type described by witnesses to the Dryden accident" (Exhibit 526, p. 75).

Validation Mr Morgan performed a thorough validation process to ensure that the computer model would fairly and accurately represent the basic behaviour of the F-28 aircraft, and the information and plots in the "Flight Dynamics" report indicated that very close agreement between the recorded performance of C-FONF and the mathematical model had been achieved. Accordingly, the authors of the report were confident that the information and results produced by the computer model were accurate.

Discussions and Conclusions

The authors of the "Flight Dynamics" report state that dynamic simulation demonstrated that the increased takeoff roll and short airborne segment could have been the result of the conditions of runway slush and wing contamination tested in the simulations. The numerical

simulations strongly support the observations made in the Fokker 100 engineering simulator. A general observation made by the authors of this report is that the higher the rotation speed and the slower the rotation rate, the greater the probability that the takeoff will be successful. This observation conforms to the advice given in the Fokker Aircraft F-28 Flight Handbook. The "Flight Dynamics" report in its conclusions emphasizes, however, that the performance subgroup treated only the aerodynamic and aircraft-handling aspects of the accident and assumed there were no other factors that could have been related to the accident. The authors emphasize that major failures of aircraft systems or other factors not mentioned in their report and not considered in the simulation could also have resulted in the accident flight profile, alone or in conjunction with the known wing contaminant.

With the above caveats in mind, the authors of the "Flight Dynamics" report concluded as follows:

1. The witness reported flight paths and "Dryden scenario" which was based on [the witness reports are] physically possible from an engineering viewpoint.
2. The aerodynamic performance of the F28 ... was definitely degraded by the wing contamination ... the contaminants on the wings degraded the lifting capability and increased the drag on the accident aircraft.
3. The increased ground distance to the reported liftoff point could have been due to the following factors, individually or in combination:
   a) Small slush accumulations on the runway
   b) Selection of higher than normal rotation speed.
4. An additional contributing factor to the increased ground distance to liftoff was the higher speed and/or pitch attitude required for liftoff as a result of wing contaminant ... This was due to the additional time required to reach the required speed [for liftoff] and/or to rotate the aircraft to the higher liftoff attitude. At the liftoff speed for the F28 in the Dryden case on the order of 130 knots, each additional second during rotation increased the ground run by approximately 200 feet.
5. The deteriorated condition of the paint on the wing leading edge probably did not affect the aerodynamic characteristics of the aircraft directly. However, the effect of the deteriorated paint on the adherence characteristics of contaminants at the leading edge is unknown, but could potentially have been a minor factor in the amount of contaminant that remained on the wing.
6. Simulation and analytical work by [the authors of the "Flight Dynamics" report] has defined a range of conditions in terms of wing and runway contaminant levels which, alone, **could** have resulted in the accident profile.

> 7. Without [cockpit voice and flight recorder] data, the pilots themselves, and a mathematical description of the wing and runway contaminant levels, it can NOT be conclusively stated that wing or runway contamination alone caused the aircraft to crash.
>
> (Exhibit 526, pp. 109–10)

Mr Morgan during testimony explained each of the above conclusions. When asked his opinion as to the cause of the accident, assuming there were no major failures of the aircraft systems and no degradation of engine performance, he stated:

> A. If there really are absolutely no other factors, my opinion would be that ... the accident was a result of the contamination beyond reasonable doubt.
>
> (Transcript, vol. 72, p. 155)

In summing up his conclusions during testimony, Mr Wagner stated:

> A. ... assuming everything else worked the way it's supposed to work and there were no failures of any sort, as we described, I would say that there is a high probability that the engineering cause of the flight profile was the contamination on the airplane.
>
> (Transcript, vol. 73, p. 78)

During his testimony, Mr van Hengst, chief aerodynamics analyst at Fokker Aircraft, was given information provided by another witness, a meteorologist. The information was that there was a minimum of 1.4 mm of rough precipitation along the wings of the F-28 in Dryden. When it was suggested by counsel: "So the conclusion, then, is that, in Dryden, with 1.4 millimetres, there is no takeoff possible" (Transcript, vol. 71, p. 124), Mr van Hengst agreed.

Particular Effects of Aircraft Contamination

Propeller-Driven Aircraft

Although the Final Report of this Commission of Inquiry primarily addresses the performance of the F-28 aircraft, information was gathered during the Inquiry regarding the performance of propeller-driven aircraft and the effect on them of wing contamination.

Although the performance study was specifically conducted for the F-28 aircraft, the results obtained are applicable to any other aircraft in

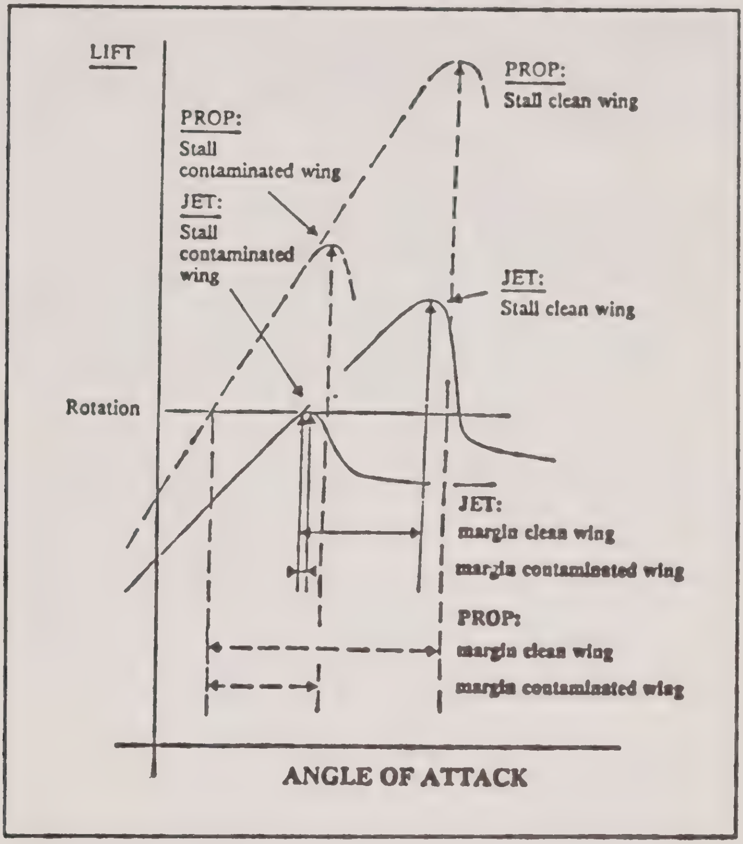
this class, that is, to any jet-propelled, swept-wing aircraft. There is, however, a more severe performance penalty paid for contamination of a jet-propelled aircraft than for contamination of a propeller-driven aircraft. The shallower lift curve slope and the reduced maximum coefficient of lift of the swept wing make its performance more readily degradable. As well, the jet aircraft does not have the advantage of a relatively large area of its wing being immersed in high-velocity air from the propeller slipstream. The jet aircraft's only lift-producing capability is the result of the aircraft motion relative to the air. Diagrams in Fokker's Report no. L-28-222 (technical appendix 2 to the Final Report) and the "Flight Dynamics" report (technical appendix 4) show performance comparisons between jet- and propeller-driven aircraft when their wings are contaminated. Figure 12-9, from the "Flight Dynamics" report, depicts the comparison.

Mr van Hengst, Fokker's chief aerodynamics analyst, was questioned about the effects of contamination on a propeller-driven aircraft as compared with a jet-driven aircraft. He concluded that it was dangerous to fly with contamination on either type and explained the peculiar danger regarding contamination on a propeller-driven aircraft. He explained that if an engine fails and the wings are contaminated, then, in effect, one wing loses the benefit of the high-energy slipstream, which results in a rolling moment in the aircraft.

Mr Richard Wickens, in researching and writing the aerodynamics portion of the "Flight Dynamics" report, also reviewed the 1930s literature on the effects of surface roughness on airfoils, the material reviewed by Fokker Aircraft during its wing-contamination studies subsequent to the F-28 crash at Hanover, Germany. Mr Wickens and NRC wanted to obtain their own data as well as more recent information to confirm both the earlier literature and the Fokker Aircraft studies conducted in 1969 on the F-28 Mk1000 aircraft. Mr Wickens also wished to determine if there were any differences among various airfoils. Since he could not simulate high Reynolds Numbers in NRC's wind tunnel to determine differences among the wing sections of various jet airfoils, he utilized a ½ model NACA 4415 airfoil with an engine nacelle and a powered propeller. The airfoil had an aspect ratio of slightly over 6. The wing had a general shape corresponding to that of a de Havilland Twin Otter and a 15 per cent thickness, somewhat similar to that of both the Twin Otter and the F-28. The wing was tested in both a clean and a roughened condition and was tested both powered and unpowered.

It was determined that a clean wing with the benefit of high-energy propeller-driven airflow would achieve about 25 per cent additional maximum coefficient of lift (C_{LMAX}) at takeoff speeds compared with the same wing without the benefit of propeller airflow. For a contaminated wing with propeller airflow, the C_{LMAX} would be similar to that of the

Figure 12-9 Jet- and Propeller-Driven Aircraft Comparison



Source: Exhibit 526, figure 1

same clean wing without propeller airflow. For a contaminated wing of a propeller-driven aircraft where the propeller airflow is lost (engine stoppage), the C_{LMAX} would be approximately the same as that of a contaminated wing of an aircraft that does not have the benefit of propeller airflow (jet aircraft).

As can be seen, if one engine of a propeller-driven twin-engine aircraft fails, the wing that loses the propeller airflow loses the increased C_{LMAX} created by the airflow. Where there are clean wings and the aircraft is flying at high airspeeds, there should be little difficulty controlling the aircraft. However, if the wings are contaminated and the aircraft is at low speed with the engines producing high power, the reduction in the C_{LMAX} caused by the engine stoppage could cause the wing that loses the propeller airflow to stall. The aircraft would then experience a rolling moment towards the failed engine. This scenario would be particularly

dangerous when the aircraft is at low altitude during takeoff; there would not be enough altitude in which to recover the aircraft.

Mr Wickens and Mr V.D. Nguyen, in a report based in part on research conducted for this Commission of Inquiry, summarized the effects of performance degradation on propeller-driven aircraft due to wing contamination:

> A wind tunnel investigation has assessed the effects of distributed upper surface roughness, and leading edge ice formation on a powered wing propeller model.
>
> In the unpowered state, it was found that roughness reduces the lift slope, and maximum lift by 30 to 50 percent, depending upon particle size and Reynolds number. The leading edge region is especially sensitive to these disturbances, however removal of the roughness over a small portion of the nose restored the wing to close to its original performance.
>
> The application of power to the wing, with an increase of slipstream dynamic pressure increases the lift slope and maximum lift; however this benefit is lost if the wing is roughened. Subtraction of the propeller reactions indicated that the slipstream interaction accounted for half the lift increase, and also resulted in reduced drag for the clean surface. This drag reduction was removed when the wing was roughened, indicating that the degradation of wing performance due to roughening is relatively greater when a slipstream is present, compared to the unpowered wing.
>
> Leading edge ice accretion causes similar large losses in lift and increases of form drag although a comparison of the two types of contamination showed that leading edge ice produces a smaller reduction of lift slope prior to flow separation. In both types of contamination, Reynolds number is important, and emphasizes the necessity of testing under near full-scale conditions.
>
> ("Wind Tunnel Investigation of a Wing-Propeller Model Performance Degradation Due to Distributed Upper-Surface Roughness and Leading Edge Shape Modification," p. 1)

The authors reach seven conclusions, of which numbers (1), (5), and (6) are particularly significant:

> 1) The main effect of distributed upper surface roughness on an unpowered wing is to reduce lift slope and maximum lift by as much as 30 to 50 per cent, depending upon roughness size, Reynolds number, and to a lesser extent, coverage.
> 2) The magnitude of the loss of maximum lift increases with roughness size, and also with Reynolds number and testing of roughened wings should be done at as high a Reynolds number as possible.

3) Roughness increases the parasite drag at zero lift and also results in a premature stall with resulting large increases of form drag.
4) The leading edge region is especially sensitive to distributed roughness regardless of particle size; there is a significant increase in drag and corresponding decrease of leading edge suction at angles of attack below stall. Conversely, removal of the roughness over a small portion of the nose restores the wing to almost clean performance.
5) If the wing is powered and clean, the slipstream interaction increases lift slope and maximum lift by 25 per cent, for thrust coefficients appropriate to the takeoff condition. If roughness is applied, maximum lift decreases by more than 25%, thus producing a lifting performance somewhat below the unpowered wing in the clean state. This may have significance in the event of an engine failure; the contaminated wing will suffer a further loss in maximum lift in the unpowered state.
6) An attempt was made to isolate the slipstream interaction on the wing by subtracting estimated propeller forces. When comparing the performance of the powered and unpowered wings, it was noted that roughness produced slightly higher losses on the wing immersed in the slipstream.
7) Loss of lift due to an accretion of rime or glaze ice on the leading edge of the wing may reach as high as 50 percent even when the wing is powered, and is sensitive to Reynolds number. Loss of maximum lift is greater for heavy rime ice than for heavy distributed roughness.

(Ibid., pp. 11, 12)

Because many air carriers operate propeller-driven aircraft, I believe that flight crews flying, and other operations personnel involved in operating, these aircraft types should have the benefit of all the information contained in this report by Mr Wickens and Mr Nguyen. I have therefore included as technical appendix 5 the entire report on propeller performance degradation, which was presented by Mr Wickens at an Advisory Group for Aerospace Research and Development (AGARD) conference on "The Effects of Adverse Weather on Aerodynamics" at Toulouse, France, on April 30, 1991.

Wing with Leading-Edge Devices versus Hard Wing

There is, in the aviation industry, some controversy over whether the effects of wing contamination during takeoff are less on aircraft that have wing leading-edge devices (e.g., leading-edge slats or leading-edge flaps) than on those that do not. A wing without leading-edge devices is often referred to as a "hard wing."

Literature suggests that deflection of trailing-edge flaps tends to increase the adverse effects of surface roughness on the maximum

coefficient of lift (C_{LMAX}). Leading-edge devices tend to suppress the adverse effects of small amounts of surface roughness; however, it is acknowledged that leading-edge devices do not suppress the adverse effects of larger levels of roughness. Aircraft such as the Boeing 737, equipped with leading-edge slats and flaps, have been reported to experience pitchup and rolloff immediately after takeoff in weather conditions that were conducive to the formation of ice and snow on the wing leading edges. In most cases, the flight crew were able to recover by using extreme control-column movements and maximum power. In the case of the Air Florida, Inc., Boeing 737 crash at Washington, DC, on January 13, 1982, where no recovery was achieved, it was found, inter alia, by the United States National Transportation Safety Board that snow and/or ice contamination on the wing leading edges produced a nose-up pitching moment as the aircraft was rotated for liftoff.

Two expert witnesses, Mr Jack van Hengst and Mr Gary Wagner, suggest that the effect of wing contamination is equally dangerous on a wing with leading-edge devices and a hard wing.

Mr Wagner, in his article "Takeoff & Landing in Icing Conditions, Aerodynamic & Performance Issues" (CALPA's *Pilot*, December 1989), states as follows:

> There has been a focus on icing accidents in Canada in recent years, especially those involving aircraft with so-called hard wings (i.e. no leading edge devices). However, analysis of the performance of aircraft with wings with leading-edge devices shows, in general terms, the same kinds of performance problems when these aircraft are operated with contamination present. Since any benefit from the leading edge devices in these conditions is small, it is suggested that pilots of aircraft so equipped take no comfort from the fact that the aircraft are slatted/slotted, etc. and that any airfoil contamination be dealt with in the appropriate way. Should the contaminant not be removed, the same magnitude of performance decrement should be expected whether the wings have leading edge devices or not.
>
> (Exhibit 550, p. 12)

In addressing his article and providing his views on the relative performance of hard wings compared with wings with leading-edge devices, Mr Wagner stated in testimony as follows:

> A. I would think the fact remains, if the airplane's not going to fly, most likely, it's not going to fly, and if you get to the point where you've got so much contaminant on and you rotate the airplane and become slightly airborne, the point I'm trying to make in the article – and I thought my words were strong enough, sir – was that, if that airplane's contaminated, you should have it cleaned and take no comfort from having a

> leading edge slat.
>
> I don't think to suggest one is better or worse than the other is appropriate, because, sir, there are so many different designs of leading edge slats, leading edge flaps, it may depend on the trailing edge flap setting – it's a very complex problem.
>
> But the simple fact is, whether the airplane is slatted, slotted, flapped or whatever, if it's contaminated, you're going to have on the order of magnitude similar performance effects of contaminant.
>
> (Transcript, vol. 73, p. 144)

Mr van Hengst explained that, in aerodynamic terms, pilot recognition of a performance problem occurs at a different time during the takeoff, depending on the type of aircraft. If the wing is contaminated, then, for a pilot of a hard-wing aircraft or an aircraft with the wing leading-edge devices retracted, the problem is evident when the aircraft is rotated for takeoff and before it leaves the runway. The aircraft may eventually get airborne but cannot fly out of ground effect. On aircraft with leading-edge devices extended, the problem may become evident to the pilot only after the aircraft becomes airborne. Thus, for aircraft types such as the Boeing 737, flight crews have described pitchup or rolloff as occurring immediately after takeoff. The results can be the same for either phenomenon: the aircraft may not be able to accelerate to a high enough airspeed to fly out of ground effect.

Whether the pilot encounters performance problems such as stall, which might be caused by contamination, at rotation of the aircraft, or whether the problem, identified by a pitchup or rolloff, is evident once the aircraft is airborne, the important issue is immediate rectification of this dangerous situation. And although the two types of wings, when contaminated, may exhibit different takeoff flight characteristics, from the evidence of the expert witnesses it is clear that the effect of the contamination on either type of wing is equally dangerous.

To highlight much of the evidence that was before me, I include the following statement made at a September 1988 de-icing conference in Denver, Colorado, by Mr Ralph E. Brumby of the Douglas Aircraft Company:

> [S]imply a listing of some icing-related accidents ... while it is by no means inclusive ... does illustrate that ice contamination is quite democratic. Straight wing propeller aircraft like the Nord 262, small turbojet aircraft with conventional airfoils like the Learjet, and larger aircraft with conventional airfoils such as the F-28, DC-9, and DC-8 as well as aircraft with leading edge high lift devices, such as the 737, are all adversely affected.
>
> (Exhibit 532, tab 10, p. 7)

Freezing Precipitation on Aircraft Surfaces

Witness Descriptions of Wing Contamination

There was much eyewitness testimony that snow accumulated on the aircraft wings during the station stop in Dryden. Various descriptions were provided as to how the appearance and amount of the snow on the wings changed during the takeoff roll and rotation.

Mr Brian Perozak, who was seated in row 4 near the front of the aircraft, and Air Ontario Captain David Berezuk, who was seated in row 12, next to the left wing, respectively described the snow on the wings as "fluffy snow" and "wet snow accumulation" in the approximate amount of one-half inch prior to the takeoff roll (Transcript, vol. 16, p. 229; vol. 14, p. 79).

Mrs Sonia Hartwick, the surviving flight attendant, who was seated in row 8, stated: "It crystallized and turned to ice" (Transcript, vol. 10, p. 239). In a tape-recorded telephone conversation with Air Ontario executives approximately one hour after the crash, Mrs Hartwick stated: "the wings were icing up ... before take off there was quite a bit of wet snow on them, as we were taking off it was freezing" (Exhibit 126, p. 2).

Mr Murray Haines, an Air Canada captain who was seated in row 13, stated: "About a third of the way down the runway, when – as the speed got up, the snow crystallized into the ice, and it wasn't moving off the wings" (Transcript, vol. 19, p. 37).

Captain Berezuk stated: "I saw it [snow] dissipate ... it was a sculptured carpet texture, the parts that were white in colour got more of a greyish opaque colour and the parts that were greyish got more grey in intensity" (Transcript, vol. 14, p. 84).

Mr Perozak, who had a clear view of the front portion of the right wing, observed at the time of initial liftoff a "donut glaze" of ice over the leading edge of the wing (Transcript, vol. 16, p. 234). The glaze was not there at the start of the takeoff. He stated: "It looked like the snow had become ice" (p. 236).

Mr John Biro, a retired Canadian airforce warrant officer who was seated in row 11 next to the right wing, testified as follows:

> A. We started to roll down the runway and at this stage I was looking at the wing rather closely, hoping that as we gained speed this wet snow would slide off.
>
> We reached flying speed at seemingly about the same time as previously. And as the nose of the aircraft lifted, the snow on the back part of the wing, about halfway up across the wing, came off with a buff, almost an explosive-type buff.

> And the snow on the forward part of the wing seemed to freeze to an opaque, dull opaque ice, almost a flash freezing type thing. And it had a rough surface, not – not coarsely rough but definitely a rough surface.
>
> (Transcript, vol. 21, p. 12)

Mr Biro also stated that right after liftoff, the painted portion of the wing became visible as the snow blew off and the forward portion of the wing became ice. The ice had a rough surface such as the surface of a "knitted coverlet on the bed ... almost a waffled surface" (p. 32), and Mr Biro agreed that there was "a noticeable difference in colour between the front and the rear of the wing" (p. 37).

Because of concerns at an early stage of the investigation regarding wing contamination, it was decided to investigate phenomena that might explain the passengers' observations and why the precipitation adhered to the wings. The assistance of the National Research Council was obtained in this regard.

National Research Council Report: "Freezing Precipitation on Lifting Surfaces"

This section of the chapter is based upon a report prepared in support of the investigation and entitled "Freezing Precipitation on Lifting Surfaces." Researched and submitted by Myron M. Oleskiw, PhD, the "Precipitation" report was entered as Exhibit 521 during his testimony. Dr Oleskiw is an associate research officer at the low temperature laboratory, Division of Mechanical Engineering, NRC. As a research meteorologist he has expertise in computer simulations relating to rime ice formation on airfoils. For brevity and simplification, much of the background information and many of the test procedures, charts, and calculations from the report are not included in this section. However, so that the technical data and the results of Dr Oleskiw's research will be available to the reader, the study appears in its entirety as technical appendix 6 to this my Final Report.

The low temperature laboratory was requested to perform the following analyses, given the known meteorological conditions at Dryden, Ontario, on March 10, 1989:

- an estimation of the weight of snow per unit area that could have collected on the aircraft prior to takeoff;
- a determination of whether wet snow crystals could have stuck to the leading-edge of the wing during takeoff; and,
- a determination of whether snow on the surface of the wing could have turned to ice (as reported by witnesses) through the mechanisms of adiabatic and evaporative cooling of the airflow over the wing.

Dr Oleskiw was also requested to research the possibility of wing surface cooling being caused after landing by cold fuel in the wing tanks, the fuel having been cooled during flight, and to determine the effect the cooling might have had on precipitation falling on the wings while the aircraft was on the ground. The phenomenon of both the aircraft skin and the fuel cooling while the aircraft is flying in very cold temperatures at higher altitudes, resulting in the aircraft skin, on landing, being colder than the outside temperature, was referred to in much of the testimony at this Commission as "cold soaking." I will deal with the phenomenon of cold soaking further in a later section of this chapter.

The following provides a summary of the "Precipitation" report.

Quantity of Precipitation Accumulated

The thickness of wet snow that would have accumulated on the wings of C-FONF during its station stop at Dryden was estimated to be 1.38 mm. This value was determined from analyses of the visibility data as recorded by an Atmospheric Environment Service observer at the Dryden terminal as well as by a transmissometer located near the threshold of runway 11. The relationship used to estimate precipitation rate from visibility is an empirical one, and the data from which the estimate was derived show considerable scatter. The main uncertainty in the relationship is due to the variation in terminal velocity of the snowflakes because of the variations in their size and wetness and, thus, density. It is expected that, despite the efforts to calibrate the visibility-to-precipitation–rate relationship, unusually wet snowflakes may have contributed to a depth of precipitation greater than 1.38 mm.

During his testimony, Dr Oleskiw stated that he did not include in his calculations any information gathered from witnesses. Being aware of witness testimony that revealed the snow had been falling in a fashion not in agreement with the "hard" meteorological data, Dr Oleskiw estimated that the depth of snow could have been up to three times his estimate of 1.38 mm. According to witness testimony, the snow was heavy and the flakes were very large. Also, the visibilities used in Dr Oleskiw's calculations were from the centre and the west end of the airport. When during his testimony it was suggested that there could have been a "curtain" of snow between the terminal and the east end of the runway, with the transmissometer isolated at the west end of the runway, Dr Oleskiw stated: "a comparatively heavy and unrecorded amount of snowfall could have been occurring at the east end of the runway" (Transcript, vol. 68, p. 281). He considered it probable that, had this information been used in snow depth calculations, the estimated snow depth would have been greater.

Dr Oleskiw estimated the accumulated water-equivalent snowfall during the time the aircraft was on the ground to be 0.50 mm. This accumulation is equivalent to 0.5 kg per square m. Because of the shape and slope of the aircraft surfaces and the consistency and wetness of the snow, it is difficult to estimate the weight of snow and slush that stayed on the aircraft.

Freezing of Accumulated Precipitation

Adiabatic and Evaporative Cooling Some of the passengers on board C-FONF saw snow blow off the wings and observed slush on the wings turn to ice during the takeoff roll, especially at or near the point of aircraft rotation. Extensive calculations were made with regard to the effects of adiabatic and evaporative cooling during the takeoff run to determine if these processes could have generated enough heat loss to account for the fact that the slush froze.

The adiabatic cooling of the air just outside the boundary layer plus the evaporative cooling caused by less than saturated air passing over the wing produced a heat loss. The heat loss was, however, more or less offset by the heat gain caused by frictional heating of the boundary layer in combination with the heat release required to freeze the partially melted snowflakes impacting on the wing. With such a small net heat flux, and given the very short time that it would have been acted upon during the takeoff roll, it would have been impossible for essentially any change to occur in the precipitation layer. Any snowflakes impinging on the wing during the takeoff roll would thus have likely met a partially wetted precipitation layer surface.

Dr Oleskiw estimated that between 25 and 32 per cent of the snowflakes that are in the path of the wing during the takeoff roll would stick to the leading edge in the area extending from 3 per cent to about 19 per cent of the wing chord. Further back on the wing the snowflakes would graze the surface and would not stick to it. The fact that the snow on the wing was partially wet, in combination with the likelihood that the impinging snowflakes would have been somewhat wet, leads to the conclusion that many of these snowflakes would have stuck to the forward portions of the precipitation layer during the takeoff roll.

Dr Oleskiw concluded that there was an insufficient amount of adiabatic and evaporative cooling during the takeoff roll to account for the freezing of the precipitation layer on the wing.

Conduction of Heat into the Fuel Tanks The wing of the F-28 contains integral fuel tanks that, when full, wet the wing skin for most of the length of the wing between two wing spars located at about 12 per cent and 56 per cent of the wing chord. For the purpose of calculating heat transfer, it was first necessary to determine the temperature of the fuel

in the aircraft before and after the aircraft was refuelled at Dryden. Calculations regarding fuel temperatures were made from the time the aircraft left Winnipeg to the time refuelling was completed at Dryden. Data considered were the initial temperature and weight of the fuel in the aircraft, the temperatures and weights of delivered and offloaded fuel, the outside air temperature both on the ground and at flight altitudes (the cold temperatures at altitude causing the fuel to cool), and the flight leg duration. During a flight of the sister Air Ontario F-28 aircraft, C-FONG, wing surface temperatures and fuel temperatures were measured to establish norms. The flight leg durations were similar to those flown by C-FONF on March 10, 1989, and the outside temperatures were approximately the same. These norms were used by Dr Oleskiw in his calculations. The temperature of the fuel in C-FONF at Dryden just prior to the accident flight was calculated at 6.4°C before fuelling and at 4.7°C after fuelling. The ambient air temperature at the Dryden airport at the time was between +0.4°C and +1.0°C.

Under certain circumstances and in combination with the other heat flux terms, the contribution of the conductive heat flux from the precipitation layer on the wing to the fuel tanks might have resulted in a complete freezing of the water fraction of the precipitation layer during the 10-minute interval of the heavier snowfall rate while the aircraft was on the ground. The assumed value of the water fraction of the falling snowflakes has been shown to alter significantly the time required to freeze the precipitation layer. The thickness of the precipitation layer also exhibited a strong influence on the freezing time.

Given that the depth of the wet snow on the wings was likely greater than the best estimate of 1.38 mm calculated from the available data, it seems probable that the heat conduction into the fuel tanks would have permitted a lower portion of the water in the wet-snow layer to have frozen, while leaving some upper portion in a partially liquid state. Because the density of the wet snow was between that of dry snow and ice, this layer was composed of a lattice of deformed and coagulated ice crystals interspersed with air pockets and water. As the water froze in the lower portion of this layer, it would likely have left a very rough interface between the lower and upper portions of the precipitation layer.

As the aircraft rolled down the runway, pressure variations outside the boundary layer and aerodynamic forces of air flowing over the wing at speeds, in places, of greater than 300 knots might have forced the remaining water in the upper portion of the precipitation layer to drain away, possibly carrying with it some of the slush, wet snow, and ice from that portion. The resulting very rough ice surface on the wings would have had a significant impact on the aerodynamic performance of the aircraft.

It should be noted that the thermal conductivity of the aluminum skin of the aircraft is in the order of 100 times greater than that of wet snow, air, or the fuel in the tanks. As a result, the aluminum skin might have conducted heat away from the precipitation layer even further forward on the wing than the location of the wing spar forming the forward wall of the fuel tanks. Thus, the rough precipitation layer surface may have extended forward to the leading edge, the more aerodynamically critical portion of the wing.

Discussion and Summary

The description given by Dr Oleskiw during his testimony provides a clear explanation of the phenomenon viewed by the passengers:

> A. ... there are pressure variations as a result of the lift that is being produced on the wing, that these pressure variations and this force of the air going over the wing could have been sufficient to suck or push the remaining water out of the upper portion of the wing – out of the precipitation layer, rather.
>
> It also could have allowed the force of the air to have taken away some portion of this wet snow on the upper portion of the precipitation, leaving behind the frozen precipitation which was entirely frozen.
>
> Now, since the crystal structure and such of this precipitation layer was very coarse, it appears to me that this motion of the air during the takeoff roll could have suddenly exposed a very rough layer, much rougher than was there prior to the takeoff roll, and that as a result, the witnesses on the aircraft that seemed to indicate that they had noticed a sudden change during the takeoff roll might have actually been seeing this sort of a phenomenon occurring.
>
> And that if that indeed did occur, it seems to me, and some of your aerodynamics experts can comment further on that perhaps, that this very rough surface would have been suddenly presented to the outer surface of the wing of the aircraft to the air flow and that that perhaps could have had a very adverse effect on the aerodynamics of the aircraft.
>
> (Transcript, vol. 68, pp. 219–20)

Findings

Dr Oleskiw's findings, with which I agree and which I adopt, are summarized as follows:

- The weight of snow and slush accumulation on the aircraft could not be determined, mainly because of the difficulty in calculating the

amount of snow and slush that would stick to the sloping surfaces of the aircraft.

- The phenomenon of the slush turning to ice during rotation and liftoff could not be adequately explained by the processes of adiabatic and evaporative cooling.
- The heat transfer from the slush to the cold fuel probably caused at least the lower levels of slush on the wing to freeze. As the water drained away from the wing surfaces during the takeoff roll, leaving mainly rough ice on the wings, the change in appearance of the slush and ice layer may have left the impression on the witnesses that the slush had turned to ice.
- The aerodynamically critical portion of the wings, the forward 15 per cent of the chord, was most likely contaminated with rough snow and ice. First, because of the conductivity of the aluminum wing skin, the cooling effect of the tank fuel would extend beyond the limits of the fuel tanks towards the leading edges, causing ice to form on the leading edges; the forward portion of fuel tank limit itself being within the first 12 per cent of the wing chord. Second, it was concluded that the wet falling snow would stick to the leading edge of the wing during the takeoff roll.

Takeoff from Wet or Contaminated Runways

A runway, whether or not in an isolated area, is considered to be contaminated when more than 25 per cent of its surface, within the required length and width being used, is covered by surface water greater than 3 mm (0.125 inch) deep, or by slush or loose snow equivalent to more than 3 mm of water. The analysis of all the information regarding the runway condition at Dryden at the time of the takeoff of C-FONF on its accident flight indicates that one-quarter to one-half inch of slush covered the runway from its east end to, at least, the intersection of taxiway Alpha, a distance of approximately 3500 feet. It is therefore concluded that the runway was, at that time, contaminated.

All the published Fokker F-28 Mk1000 takeoff information contained in the Fokker F-28 Flight Handbook is based on acceleration and stopping taking place on hard, dry, and smooth runway surfaces and all means of braking being serviceable. The effects of variable factors such as temperature, moisture, density altitude, and wind on aircraft performance are also taken into account.

The takeoff performance criteria, applicable to commercial jet aircraft, including the Fokker F-28 Mk1000, are normally described as accelerate-stop and accelerate-go criteria.

In general terms, for the purpose of aircraft certification, accelerate-stop distance is defined as the distance required for an aircraft to accelerate to decision speed V_1 with all engines operating normally at takeoff thrust; to experience a power failure of the critical engine[10] at V_1; to allow an appropriate time delay for the pilots to recognize the failure and, upon recognition, allow an appropriate time to retard all engine throttles or thrust-levers to idle; to apply maximum wheel-braking and deploy speed brakes; and to continue with maximum braking until the aircraft comes to a full stop. Although reverse-thrust is not taken into account in the accelerate-stop calculation, pilots, to assist in stopping the aircraft, would also deploy and use thrust-reversers, if available, on the operating engine(s). (The F-28 does not have thrust-reversers.) The accelerate-stop distance is dependent upon such variables as wind, ambient temperature, aerodrome elevation, runway slope, aircraft weight, and aircraft configuration.

The takeoff path distance, often referred to as the accelerate-go distance, is in general terms the distance required for an aircraft to accelerate to decision speed V_1 with all engines operating normally at takeoff thrust; to experience a power failure of the critical engine at V_1; to allow an appropriate time delay for the pilots to recognize the failure and, upon recognition, elect to proceed with the takeoff and rotate the aircraft at a speed of not less than V_R to the target pitch attitude; and to achieve V_2 prior to or at a height of 35 feet above the end of the runway (often referred to as the screen height).

A runway length that allows for either accelerate-stop or accelerate-go once an aircraft experiences an engine failure at V_1 is called balanced field length or a balanced field.

Taking off from a contamination-covered runway will adversely affect the takeoff performance of an aircraft in different ways, depending on the type and the amount of precipitation on the runway. Slippery runways with little contaminant depth will adversely affect an aircraft's accelerate-stop performance but will not appreciably affect its accelerate-go performance. Although a slippery runway will reduce an aircraft's wheel-braking performance, it creates no significant drag to reduce the acceleration of the aircraft.

Accelerate-stop and accelerate-go performance are both adversely affected in conditions where the runway is contaminated with standing water, slush, or snow. Acceleration is adversely affected by wheel drag in the contamination and by the effects of spray thrown upwards against

[10] Critical engine is the engine whose failure causes the most adverse effect on the aircraft characteristics relative to the case under consideration. For the purpose of discussion of F-28 performance, neither engine, if it failed, would have had a more adverse effect than the other on aircraft performance.

the aircraft underbody by the aircraft wheels. This drag results in an increase in the distance that an aircraft requires to accelerate to V_1, to V_R, and, finally, to V_{LOF} (the liftoff speed).[11] Where an engine failure occurs at V_1 and the decision is made to go, the drag caused by the contaminant may decrease acceleration to the extent that it would be impossible to accelerate to liftoff speed after the engine failure. Where the decision is made to reject the takeoff and bring the aircraft to a stop, the reduction in the runway coefficient of friction caused by the contaminant will result in an increased stopping distance.

Because of the difficulty in predicting accurately the effect of runway contamination on acceleration and braking performance, aircraft flight manuals generally recommend that takeoffs from runways covered with standing water, slush, or snow be avoided where possible. In spite of general improvements in techniques at clearing contaminants from runways, Fokker recognized that operators might find it necessary to take off from contaminated runways. The Fokker F-28 Flight Handbook contains information to allow calculation of aircraft takeoff performance when operating from hard-surface runways contaminated with standing water, with slush, or with loose, uncompacted snow.

The Piedmont and the USAir F-28 operations manuals, which were the manuals used by Air Ontario in its F-28 operation, also contain information regarding contaminated runways, along with a caution regarding performance degradation. The following passage appears in both manuals:

> Apart from the substantial increase in stopping distance when takeoff is rejected on a contaminated runway, the degradation in acceleration caused by snow, slush or standing water can under adverse conditions result in the aircraft needing up to twice the normal takeoff distance.
>
> (Exhibit 307, p. 3A-24-4; Exhibit 329, p. 3-125-7)

Recognizing the negative effects that standing water, slush, or snow have on takeoff performance, both Piedmont and USAir provided identical correction charts recommending maximum allowable takeoff weights for various runway lengths. Inasmuch as Air Ontario pilots used the Piedmont and USAir F-28 operations manuals as guides in their day-to-day operation of the F-28, and because witness evidence indicates that there was one-quarter to one-half inch of slush on at least the east half of runway 29 at the time C-FONF commenced its final takeoff roll at

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[11] V_{LOF}, the liftoff speed, is, in terms of calibrated airspeed, the speed at which the aircraft first becomes airborne. The aircraft is deemed to be airborne when the aircraft wheels are no longer in contact with the runway.

Dryden on March 10, 1989, I think it important to include, as figure 12-10, the Piedmont and USAir takeoff limitation and correction chart.

The normal operations sections of the Piedmont and the USAir F-28 operations manuals set out identical correction charts. The above-noted excerpt from the two manuals was included by Air Ontario in the first draft of its F-28 operations manual but was removed from the draft of the manual submitted to Transport Canada for approval. The chart was removed after discussion with the drafters, Captain Robert Perkins and Captain Steven Burton; the project manager of the F-28 program, Captain Joseph Deluce; and the director of flight standards for Air Ontario, Captain Larry Raymond. The discussions centred on the fact that the Piedmont charts were much more restrictive than the Fokker F-28 charts.

The contaminated runway performance charts produced for the F-28 aircraft by Piedmont, USAir, and Fokker were all based on the assumption of both engines operating normally throughout the takeoff flight path.

Using Fokker charts and the takeoff distance available of 6200 feet on runway 29 at Dryden, with a temperature of +1°C, a barometric pressure of 1020 millibars, and a tail-wind component of 1 knot (the conditions that existed at Dryden on March 10, 1989), with one-half inch of slush (EWD 0.425 inches), the operations group calculated that the maximum allowable takeoff weight of an F-28 would be 64,400 pounds. Under the same conditions, the Piedmont and USAir charts provided that the maximum allowable takeoff weight of an F-28 would be somewhere between 53,000 and 54,300 pounds.

Two matters that arise from the performance information available to Air Ontario F-28 pilots relating to operation from contaminated runways are of concern to me. My first concern is over the large difference between the correction factors provided by Fokker Aircraft and those supplied in the Piedmont and USAir operations manuals used by Air Ontario. My second concern is that the contamination-correction charts do not consider engine failure during takeoff; the charts are based on both engines operating throughout the takeoff flight path. Although information is provided to pilots for the determination of allowable aircraft weight and balanced field lengths when operating from a dry runway, no equivalent information is provided for takeoffs from a contaminated runway.

The chart provided in the Piedmont and USAir operations manuals imposes severe weight penalties for takeoff on slush-covered runways. If we assume the takeoff portion of the runway at Dryden was covered with one-half inch of slush, then, had the crew of C-FONF, prior to takeoff, referred to and complied with the information set out in the Piedmont and USAir manuals, they would not have been able to take off

Figure 12-10 Piedmont/USAir Takeoff Weight Correction Chart for a Contaminated Runway

5. Takeoff in Standing Water, Slush or Snow

Operation on precipitation covered runways is acceptable, however an assessment for the deteriorating effect on takeoff performance must be made. The following information is presented for guidance and has not been FAA approved.

This part contains information and recommendations to enable an assessment to be made at which the airplane should be able to take off from a snow, slush or water-covered runway. The precipitation is assumed to be of uniform depth over the complete length of the runway.

Takeoff in standing water depths greater than 0.25 inch, slush depths greater than 0.50 inch or dry snow greater than 2.0 inches is not recommended. The maximum takeoff weight shown in the following table is based on both engines operating throughout the takeoff flight path. The weights shown are always lower than dry runway take-off allowable weights. Therefore, no comparison is required. These are the maximum allowable takeoff weights on contaminated runways.

F28 MK 1000 CONTAMINATED RUNWAY
MAXIMUM ALLOWABLE TAKEOFF WEIGHT
FLAPS 18°

RUNWAY LENGTH - FT	STANDING WATER 0.25 INCHES	SNOW = 1.0 INCHES SLUSH = 0.25 INCHES	SNOW = 2.0 INCHES SLUSH = 0.50 INCHES
5000	48800 lbs	52700 lbs	49500 lbs
5500	49800 lbs	54000 lbs	51500 lbs
6000	50800 lbs	55400 lbs	53000 lbs
6500	51900 lbs	56800 lbs	54300 lbs
7000	52900 lbs	58000 lbs	55600 lbs
7500	53800 lbs	59100 lbs	56600 lbs
8000	54700 lbs	60100 lbs	57500 lbs
8500	55600 lbs	61000 lbs	58200 lbs
9000	56300 lbs	61700 lbs	58900 lbs
9500	56900 lbs	62200 lbs	59500 lbs
10000	57300 lbs	62600 lbs	60100 lbs

Note: This information is good for all temperatures and for airport elevations up to and including 3,000 feet.

Source: Exhibit 307

unless the runway had first been cleared of slush or the aircraft weight had been no greater than 54,300 pounds. Calculations using the Fokker charts for the same conditions at Dryden indicate that there was sufficient runway for an F-28 to take off at a weight of 64,400 pounds, even though there was one-half inch of slush on the runway. The large variation in permissible takeoff weights between Fokker Aircraft and Piedmont/USAir clearly indicates a difference between the manufacturer's certification requirements and the operational philosophy of Piedmont and USAir. A carrier that is conservative in its view of the requirements concerning contaminated runways might impose severe restrictions, as was the case with both Piedmont and USAir. The draft of the Air Ontario F-28 operations manual that was sent to Transport Canada did not contain a slush-correction chart. A less conservative carrier could simply adopt the less restrictive chart provided by Fokker Aircraft. Even so, approval of all the slush-correction charts mentioned is not required by Canadian, Dutch, or United States regulatory authorities.

Captain Robert Perkins, an Air Ontario F-28 check pilot, stated in his testimony that, because the Piedmont and USAir F-28 slush-correction charts were "fairly restrictive" (Transcript, vol. 43, p. 31), he felt he could use the Fokker F-28 Flight Handbook chart, which was less restrictive. However, while under close questioning during his testimony, he agreed with the subsequent evidence of Transport Canada and Air Ontario pilot witnesses that, to determine takeoff parameters, a pilot in the cockpit would find it difficult and time-consuming to use the detailed charts in the Fokker handbook. Captain Robert Nyman, the director of flight operations for Air Ontario, considered that the tables in the Piedmont and USAir F-28 operations manuals applied because these were the manuals used by Air Ontario F-28 pilots. With respect to Fokker's charts, Captain Nyman stated: "I tried post-accident to go through those charts. I have been trained in performance and use of charts. I found them very difficult to use, and, as has been pointed out by other people, you don't come up with consistent answers. I find them difficult to use" (Transcript, vol. 109, p. 210). During this Commission's hearings, testimony revealed that, within the pilot group of Air Ontario, there was no consensus on whether to use Fokker's or Piedmont's information with respect to operations from slush-covered runways. Clearly this lack of consensus constituted an alarming state of affairs within Air Ontario.

In light of testimony about the nature of the charts contained in the Fokker F-28 Flight Handbook, it is not only probable but virtually certain that the crew of C-FONF had insufficient time to use them to determine slush corrections. Moreover, the fact that C-FONF, at an estimated weight of 63,500 pounds, took off at Dryden from a slush-covered

runway strongly suggests that the crew either did not consider or considered and elected not to apply the slush-correction information contained in both the Piedmont and USAir F-28 operations manuals. The uncertainty regarding which manual to use in calculating slush correction at Dryden would have posed a serious dilemma for the pilots of Air Ontario flight 1363. That dilemma should have been solved by Air Ontario long before March 10, 1989.

The final takeoff of C-FONF was from a runway contaminated with slush on at least the first half of its length and wet on the remainder. The slush was described by a number of witnesses, none of whom had actually measured its depth, as being up to one-half inch deep. The performance subgroup determined through precise analytical and engineering studies that, for the aircraft to reach its rotation point as described by many witnesses, the slush must have been in the order of 0.15 inches EWD. Although an engine failure did not occur, there was potential for the necessity to react to an engine failure during the takeoff and either continue the takeoff or stop on the runway. Calculations show that, according to aircraft weight and existing ambient conditions, the Dryden runway was close to balanced length for dry runway operations. Had an engine failure occurred at or near V_1 during the takeoff, it is probable that, because the last half of the runway was at least wet and thus slippery, the aircraft could not have been stopped on the runway. However, had there in fact been no slush on the last half of the runway, the aircraft, under normal circumstances, should have been able to complete the takeoff had an engine failed at V_1. Simulator tests conducted by the performance subgroup and Fokker Aircraft at Fokker's facility in Amsterdam indicated that, with one-half inch of slush on the entire runway length and with the aircraft wing clean, the aircraft would reach V_1 in about 3100 feet with a takeoff run of approximately 4250 feet. Engine-failure tests were not conducted under these conditions. If, however, an engine had failed at V_1, it is possible that, because of the slush, the aircraft would not have been able to get airborne in 6000 feet, the length of the runway at Dryden.

Neither United States Federal Aviation Regulations, which are the benchmark regulations for certification requirements for most transport aircraft, nor Canadian Air Regulations and Air Navigation Orders address the issue of engine failure during takeoff on a wet or contaminated runway; indeed, there are no standards available to enable manufacturers or operators to determine what weight corrections to apply. It is therefore not difficult to conclude, as in fact I do, that passengers and aircraft crew members are exposed to different degrees of risk on takeoff, depending on whether the takeoff is made on a contaminated or wet runway or it is made from the same dry runway.

Clearly this is an aviation safety issue that has existed for some time and must be addressed. As shown in a subsequent chapter of this Report, available information indicates that regulators are finally taking steps to address the problem.

The fact that Transport Canada and CASB have been aware of the problem for a considerable time is illustrated by the following abbreviated versions of two occurrence reports prepared by CASB, by the recommendations contained in those reports, and by Transport Canada's reaction to the recommendations.

The following information is from CASB report no. 86-A60024. On July 20, 1986, a Boeing 737 was taking off from Wabush, Newfoundland, when, as the aircraft speed approached V_1, a bird was ingested by the left engine and the engine lost power. The crew rejected the takeoff, and the aircraft came to a stop in a bog 200 feet beyond the end of the runway. No one was injured in the occurrence. CASB determined that, because the runway was wet, the distance required to stop the aircraft exceeded that which was available. Pre-flight performance calculations did not take into account the effects of the wet runway. Such calculations were not and are not required by regulations. CASB also found that existing aircraft flight manuals do not provide data that take into account the effects of wet runways on accelerate-stop distances.

The "safety action" portion of the CASB-produced report of this occurrence states the following:

> In view of the absence of certificated performance data and the apparent lack of knowledge on the part of flight crews regarding wet runway takeoff performance, the CASB recommends that:
>
> > The Department of Transport revise air carrier procedures involving wet runway take-off operations, in order to provide a margin of safety comparable to that for dry runway operations.
> > CASB 87-45
> >
> > The Department of Transport require air carriers to improve flight crew knowledge of the effects of wet runways on take-off performance and the means available to flight crews to provide a margin of safety comparable to that for dry runways.
> > CASB 87-46

Transport Canada's response to the above recommendations was as follows:

> Notwithstanding the amount of information available at present, Transport Canada will request the Transport Development Centre to initiate a research project to investigate the effect of wet runways on aircraft performance.

In a return letter to Transport Canada, CASB expressed regret that Transport Canada's response was limited to a long-term study. CASB further expressed concern that overruns can continue to happen whenever a rejected takeoff occurs at or near V_1 on a performance-limited wet runway and requested that Transport Canada reconsider its position on this important issue.

The following information is from CASB report no. 86-P64053. On July 14, 1986, a Boeing 737 landed at Kelowna, British Columbia, shortly after a torrential rain storm. During the landing roll, the aircraft hydroplaned, the thrust-reversers and ground-spoilers did not deploy, and the aircraft overran the runway. CASB determined that the pilot's landing procedures on the wet runway, combined with limitations imposed by the aircraft's air-ground logic system, prevented deployment of the ground-spoilers and reversers. As a consequence, the crew was unable to stop the aircraft on the runway.

With regard to wet runway performance, the "safety action" portion of this report contains the following rather startling information:

> The CASB has knowledge of 16 occurrences involving aircraft weighing more than 12,500 pounds overrunning the runway on landing in Canada between 1980 and 1987. Most of these involved runways where the braking action was reduced by water or other surface contaminants. Canadian operators routinely conduct flight operations on wet or otherwise contaminated runways that are at or near the certified performance limits of aircraft within their fleets. The latitude for error is small. The anticipated stopping distances contained in aircraft flight manuals will not be achieved if braking action is poor.

CASB pointed out in the report that existing certification standards used for determining the landing distance applicable to transport-category aircraft certified under Federal Aviation Regulation 25 require that the tests be conducted on bare, dry, smooth, hard-surfaced runways. Without detailing the issues brought to light in this occurrence, other than the wet runway performance, I will recite the CASB recommendation made as a result of this investigation. CASB recommended that:

> The Department of Transport ensure that the recurrent training of flight crews of transport-category aircraft emphasizes the cumulative performance penalties and the uncertainties of expected stopping distances associated with operations on wet or contaminated runways. Particular emphasis should be placed on the need for a timely decision to effect a successful go-around.
>
> CASB 88-05

Although not making a recommendation regarding the lack of certification requirements for aircraft-stopping performance on wet or contaminated runways, CASB did state a concern on this issue as follows:

> The Board is equally concerned that the aircraft certification criteria currently in existence for ascertaining contaminated runway landing performance data do not provide aircrew with sufficiently accurate data upon which to base landing decisions. Current procedures provide for safety margins that are derived from factoring the dry landing distances by arbitrary amounts. Consequently, flight crews often land on performance limited runways using performance data for which there is no empirical evidence to assure a stop on the available runway.

The response to CASB by Transport Canada regarding the above recommendation CASB 88-05 was as follows:

> Transport Canada air carrier inspectors have been instructed to monitor training for landing on contaminated runways and to be alert to any degradation of standards.

This is apparently the last correspondence between CASB (now the TSB) and Transport Canada relating to the above-noted occurrences and the issue of wet or contaminated runways.

On February 5, 1991, based on occurrence investigations, in particular that of the Boeing 737 overrun at Wabush, and on other information collected, and after evidence on this subject was heard before my Commission of Inquiry, Transport Canada issued Airworthiness Manual Notice of Proposed Amendment, NPA 91-2, File No: 5009-006-525, entitled, "Take-off from Wet and Contaminated Runways." The proposed amendment requires a change to the airworthiness requirements of chapter 525, paragraph 525.1581, by the addition of a new subparagraph (g) as follows:

> The Aeroplane Flight Manual shall contain information in the form of approved guidance material for supplementary operating procedures and performance information for operating on wet and contaminated runways.

The proposal is intended to ensure that suitable approved guidance information is provided in the aircraft flight manual by the aircraft manufacturer as part of the aircraft type design.

In the explanatory information that accompanied the proposed amendment, Transport Canada outlined the approach of the United States Federal Aviation Administration (FAA) and the European Joint

Aviation Authorities (JAA) with regard to wet or contaminated runways, and I quote from the document as follows:

> The FAA published Advisory Circular AC 91-6A on May 24, 1978 which provides information, guidelines and recommendations concerning the operation of turbojet aircraft when water, slush, and snow are on the runway. This AC discusses the performance problems, provides sample performance adjustments and states that appropriate information should be included in the operations manual of the air carrier. A proposed revision, AC 91-6B, was announced in the Federal Register on August 1, 1986, but has not yet been promulgated. This draft revision updates the AC and clarifies that the operational requirements in Part 121 (for Commercial Operators of Large Aircraft) and Part 135 (for Air Taxi Operators and Commercial Operators) require adjustments to take-off and landing data when operating on wet or contaminated runways. The revised AC also states that the information should be included in the AFM [aircraft manufacturer's aircraft flight manual] or in the [aircraft] operations manual but that if the information is provided in the AFM then it need not be FAA approved.
>
> In November 1987, the FAA published NPRM [Notice of Proposed Rulemaking] 87-13, Standards for Approval of a Reduced V_1 Methodology for Take-off on Wet and Contaminated Runways. The proposal introduces the concept of using a 15-ft screen height (in lieu of 35 ft) for wet and contaminated runways with a corresponding reduction in V_1. Although actual accelerate-stop performance is not required, it is implicit in the proposal that rejected take-off safety would be improved on wet or contaminated runways at the expense of a reduced screen height. To date there has been no new regulations arising from this NPRM.
>
> The European JAA have published JAR 25X1591 which requires supplementary performance information to be furnished by the manufacturer in an approved document in the form of guidance material to assist operators in developing suitable guidance recommendations or instructions for use by their flight crews when operating on wet or contaminated runway surface conditions. It further states that if the information is in the [aircraft manufacturer's] AFM, then it must be segregated, identified as guidance material, and clearly distinguished from the operating limitations specified in JAR 25.1533 and 1587.

It is apparent that at this time no regulatory body is prepared to go so far as to make it mandatory for aircraft to comply with balanced field criteria when operating on a wet or contaminated runway. There is,

however, consensus that guidance material is required. It is stated in the Transport Canada amendment document that, since the information will be provided as guidance only, non-compliance will not affect airworthiness approval; it will remain an operational decision covered by the appropriate operating regulations and/or procedures for each operator. Because of the difficulty in defining the exact state of a contaminated runway surface, in practice an aircraft may or may not perform as predicted in the guidance material. However, the mandatory inclusion in a manual, AFM or other, of approved guidance material relating to operations on a wet or contaminated runway will, in my view, go a long way towards improving the safety of such an operation. Operational decisions should be based on expected performance and not on guesswork, as is the case at present.

It appears that various regulatory bodies are working actively towards a solution to the problem of operating aircraft safely from wet or contaminated runways, and that their proposed amendments to the regulations, if they are in fact all promulgated, will improve passenger and crew safety.

However, it is doubtful that mere guidelines will produce the desired safety results. Although operators may endorse the approved guidance material, in the absence of any compulsion to follow it they have the option of ignoring it. As well, because of the previously mentioned difficulty regarding the definition of the state of the runway surface, adherence to guidelines will not necessarily ensure that a particular aircraft can be operated safely on a particular wet or contaminated runway. I believe that the regulators, in cooperation with manufacturers and operators, should continue to search for a technically accurate means of defining runway surface conditions and their effects on aircraft performance, and for an equitable means of requiring operators to adhere to balanced field criteria when operating on wet or contaminated runways. I recognize that economic penalties on air carriers would be imposed, but only through the regulatory process can a uniform and high level of safety be assured for all operating conditions.

Notwithstanding the efforts being made by the regulators with regard to aircraft performance on wet or contaminated runways, airport operators should make a concerted effort to ensure that runways are not contaminated when aircraft are landing and taking off.

Information and Procedures Available for Safe Operation in Cold Weather Conditions

This section outlines the information and procedures regarding operation in cold weather conditions that were accessible to Air Ontario F-28 pilots, including the crew of C-FONF. Chapter 1.7.5.1, Section 1, Volume 1, of Fokker's F-28 Flight Handbook provides the following information and procedures for a safe operation of the F-28 in cold weather conditions:

1.7.5 ADVERSE WEATHER

1. COLD WEATHER OPERATION

This chapter contains information and procedures for a safe operation of the F-28 in cold weather conditions. For performance criteria see subsection 2.

1.1 General

Small and apparently insignificant ice and snow deposits on the aerodynamic surfaces, accumulated during stand-over, can seriously affect the maximum lift of the wing, the controllability and the performance of the aircraft.

During a normal take-off the angle of attack reaches approx. 9 deg at rotation.

Thin layers of ice resulting from, for instance, frost or freezing fog, may cause a certain sandpaper roughness of the wing and tail upper surfaces.

This roughness may cause airflow separation at angles of attack below 9 deg resulting in control problems, wing drop or even a complete stall shortly after rotation.

Relatively "warm" fuel uplifted during a ground stop may cause dry snow falling on the wing to melt. After a subsequent cooling period this water may refreeze, forming an invisible ice coating underneath the dry snow.

When the tanks contain sufficient fuel of sub zero temperatures as, for instance, may be the case after long flights at very low ambient temperature, water condensation or rain will freeze on

> the wing upper surfaces during the ground stop forming a smooth, hardly visible ice coating.
>
> During take-off this ice may break away and at the moment of rotation enter the engine causing compressor stall and/or engine damage.
>
> Snow falling on "warm" leading edges will melt and may form, under certain wind conditions, "run back ice" on wings and stabilizer, causing possible lift loss and/or controllability problems.
>
> IN VIEW OF THE ABOVE IT IS OF VITAL IMPORTANCE THAT FUSELAGE, WINGS, ENGINE INTAKE AREAS, TAIL SURFACES, CONTROL SURFACES, HINGES AND IN PARTICULAR WING AND STABILIZER LEADING EDGES ARE COMPLETELY CLEAR OF ICE OR SNOW BEFORE TAKE-OFF.
>
> It is recommended that, when operating in slush conditions, deicing grease or fluid is applied to the lower and upper surfaces of the flap vanes and the wing shroud and flap areas which come in contact with the vane surface.
>
> The effectivity of pre-flight application of de-icing fluid is influenced by several factors such as the amount of snow or ice deposits, outside air temperature, relative humidity, aircraft skin temperature and the water/glycol mixture used.
>
> Arrange the departure so that a minimum of time elapses between the moment of de-icing and take-off.
>
> When spraying with passengers and/or crew on board, switch off the airconditioning units to prevent glycol fumes from entering the cabin and/or cockpit.
>
> (Exhibit 314, Fokker F-28 Flight Handbook, p. 1.7.5.1)

Both the Piedmont and the USAir F-28 operations manuals repeat much of Fokker's information and provide the following under the title "Cold Weather Operations":

> This section contains information and procedures for a safe operation of the F-28 in cold weather conditions. Most recommendations mentioned are a result of experience gained during winter operation in Northern Europe, Canada and the Northern States of the USA.
>
> Small and apparently insignificant ice and snow deposits on the aerodynamic surfaces, accumulated during stand-over, can seriously

affect the maximum lift of the wing, the controllability and the performance of the aircraft.

During a normal take-off, the angle of attack reaches approximately 9° at rotation. Thin layers of ice resulting from frost or freezing fog cause a certain sandpaper roughness of the wing and tail upper surfaces. This roughness may cause air-flow separation at angles of attack below 9° resulting in control problems, wing drop or even a complete stall shortly after rotation.

Relatively warm fuel uplifted during a ground stop may cause dry snow falling on the wing to melt. After a subsequent cooling period this water may re-freeze, forming an invisible ice coating underneath the dry snow.

When the tanks contain sufficient fuel of sub zero temperatures as may be the case after long flights at very low ambient temperature, water condensation or rain will freeze on the wing upper surfaces during the ground stop forming a smooth, hardly visible ice coating.

During take-off this ice may break away and at the moment of rotation enter the engine causing compressor stall and/or engine damage.

Snow falling on warm leading edges will melt and may form run back ice on wings and stabilizer, causing possible lift loss and/or controllability problems.

IN VIEW OF THE ABOVE IT IS OF VITAL IMPORTANCE THAT FUSELAGE, WINGS, ENGINE INTAKE AREA'S, TAIL SURFACES, CONTROL SURFACES, HINGES AND IN PARTICULAR WING AND STABILIZER LEADING EDGES ARE COMPLETELY CLEAR OF ICE OR SNOW BEFORE TAKE-OFF.

(Exhibit 307, Piedmont F-28 Operations Manual, p. 3A-24-1; Exhibit 329, USAir F-28 Operations Manual, p. 3-125-1)

Both the Piedmont and USAir operations manuals discuss de-icing procedures under identical headings: "Fluids for De-Icing and Anti-Icing." I quote the Piedmont provisions in their entirety as follows:

It is recommended that, when operating in slush conditions, de-icing fluid is applied to the lower and upper surfaces of the flap vanes and the wing shroud and flap areas which come in contact with vane surface.

For different de-icing fluids the times of protection (the holdover times) vary considerably. Furthermore, these times depend to a large extent on the meteorological conditions and methods of application.

The time of protection will be shortened, for instance, by snow, increasing content of moisture, wet airplane surface, relative high temperature of airplane surface and of the fluid being used, or high wind velocity and unfavorable wind direction. All these conditions cause an unwanted dilution of the protective film. If these conditions accumulate, the time of protection can be shortened considerably.

<u>CAUTION:</u> PRIOR TO EXTERIOR DE-ICING, THE APU AND PACK SHOULD BE SHUT DOWN.

If possible, ground power should be used to satisfy electrical needs during de-icing. Prior to de-icing, an announcement should be made to the passengers advising them that de-icing will be accomplished and slight fumes or smoke may be present following the de-icing operation. After de-icing is accomplished, start the APU and permit it to operate approximately two (2) minutes prior to turning on a pack.

Engine Anti-ice must be ON during all ground and flight operations when in icing conditions and/or the ice detect light is illuminated.

When penetrating or operating in icing conditions in-flight maintain a minimum of 83% HP RPM to ensure full and simultaneous Engine and Airfoil Anti-icing operation.

Icing conditions exist when OAT is 50°F/10°C or less and visible moisture in any form is present (such as clouds, fog with visibility of one mile or less, rain, snow, sleet, ice crystal); or standing water, slush, ice, or snow is present on the ramps, taxiways or runways.

(Exhibit 307, Piedmont F-28
Operations Manual, p. 3A-24-2)

None of the above information contained in Fokker's F-28 Flight Handbook or set out in the Piedmont and USAir F-28 operations manuals is contained in the Air Ontario Draft F-28 Operations Manual dated June 1, 1989. The only provisions contained in the Air Ontario Flight Operations Manual (September 15, 1987) dealing with wing contamination while on the ground and its effects is contained in section 7, "Operational Directives." One short sentence under 7.1.1, "Icing Conditions," states: "Take-off shall not be attempted when frost or freezing precipitation is adhering to the surfaces of the aircraft" (Exhibit 146, p. 73). This prohibition is included in the broader operational directive dealing generally with in-flight operating procedures in icing

conditions. As a flight operations directive, this prohibition applies to all aircraft, including the F-28. However, no information and procedures by way of advice and cautions, as appear in the Piedmont, the USAir, and the Fokker manuals, are provided.

The obvious lack of information, advice, and direction relating to ground-accumulated wing contamination in the Air Ontario Draft F-28 Operations Manual and the Air Ontario Flight Operations Manual suggests a lack of thoroughness, rigour, and understanding on the part of the drafters of these manuals. There was unambiguous information in the Piedmont and USAir operations manuals as well as in the Fokker F-28 Flight Handbook available to both Captain Morwood and First Officer Mills. (It is normal for pilots to carry their own operations manuals and for the flight handbook to be on the aircraft at all times.) It is the evidence of a number of Air Ontario pilots that the ground school course provided by Piedmont was excellent: the effects of contamination on the aerodynamic performance of the F-28 were discussed in detail, and the pilots were appropriately cautioned.

The Phenomenon of "Cold Soaking"

The portion of the Fokker F-28 Flight Handbook chapter that I have quoted warns about small and apparently insignificant ice and snow deposits seriously affecting the lift capability and controllability of the aircraft, possibly causing, in turn, a complete stall shortly after takeoff. Fokker also warns about the possibility of dry snow falling on a wing containing warm uplifted fuel, potentially resulting in a thin-ice coating on the upper wing surface. Fokker speaks of wing-tank fuel at subzero temperatures causing water condensation or rain to freeze to the upper surfaces of the wing while the aircraft is on the ground. Finally, Fokker Aircraft insists that it is of vital importance that the aircraft be completely clear of ice or snow before takeoff. The Piedmont and USAir F-28 operations manuals reiterate Fokker's information, cautions, and instructions.

As noted above, the F-28 manuals are referring in part to a phenomenon that may be understood by most pilots but is by no means fully understood by all pilots; that is, cold wing-tank fuel causing precipitation to freeze to the aircraft surfaces. "Cold soaking" is a term used to indicate that an object has been in a cold temperature long enough for its temperature to drop to, or near to, the ambient temperature. Temperature at altitude is almost always colder than at ground level, and, although the outer skin of an aircraft in flight will cool quickly, the fuel in the wing tanks, because of its latent heat properties, will cool more slowly. The longer the aircraft remains at altitude, the closer the temperature of the fuel will be to the ambient temperature. On landing,

the reverse occurs. The skin of the aircraft will warm quickly to ambient temperature, while the fuel will warm more slowly. However, the aircraft skin that is touched by the cold-soaked fuel will remain close to the temperature of the fuel touching it.

A well-known phenomenon frequently occurs on an aircraft that has landed with cold-soaked fuel in the wing tanks: moisture from the air deposits in the form of frost on the surfaces that are touched by the cold fuel. These frost deposits form under the wing tanks. On landing, the fuel in the wing tanks is normally depleted; since there is no tank fuel to touch the skin on the top of the wings, there usually will not be a frost deposit on the upper wing surface.

On occasion, however, there will still be enough cold fuel in the tanks on landing to touch the skin on the top of the wings. Addition of fuel at a warmer temperature will raise the level of fuel to touch the upper surface of the wing but may not bring the resultant temperature of the fuel above the freezing level. Frost can then form on the upper surface of the wing that is touched by the cold fuel. Rain can freeze to the upper wing surface in the form of a smooth, transparent sheet of ice, often virtually invisible; falling wet snow can also freeze to the upper wing surface, and the resulting ice surface may not be smooth.

As shown in the study by Dr Oleskiw and as evidenced during his testimony at the Inquiry, the cold-soaking phenomenon was at work at Dryden during the time C-FONF was on the ground prior to the crash. There can be little doubt that wet falling snow froze to the upper surfaces of the wings and ultimately prevented the aircraft from flying.

During the Inquiry, Air Ontario pilots were asked of their knowledge of cold soaking. Most were aware of the phenomenon, but some pilots had no knowledge of it prior to the crash of C-FONF. As shown above, all the F-28 manuals to which the Air Ontario pilots had access contain some information regarding the cold-soaking phenomenon, although the term "cold soaking" is not used.

The Piedmont and USAir F-28 operations manuals also present information to pilots on the use of de-icing fluids and include a caution that the time of protection against freezing provided by such de-icing fluids can be shortened considerably, depending on type of snow, moisture content, temperature of aircraft surfaces, and type of fluid being used. The Piedmont and USAir F-28 operations manuals in particular warn that icing conditions exist when the outside air temperature is +50°F/+10°C or less and visible moisture in any form is present, or standing water, slush, ice, or snow is present on the ramps, taxiways, or runways.

In view of all the cautions, warnings, and instructions provided by the Fokker F-28 Flight Handbook and the Piedmont and USAir F-28 operations manuals, one wonders what more information should have

been provided to the pilots of C-FONF to convince them that takeoff in weather conditions which are conducive to the formation of ice or frost on the wing can be completed only when such conditions have been assessed and dealt with appropriately. Although de-icing and anti-icing are available, I am of the view that, for safe aircraft operations, a thorough understanding of all aspects of wing contamination is necessary, including its formation, removal, and prevention, and its effects on the aerodynamics of aircraft. This understanding can be accomplished only through education and training.

Assessing the Condition of the Outside of the Aircraft

The requirement to take off with a "clean aircraft" necessitates that the aircraft be inspected before takeoff if weather conditions are such that there is any suspicion of the wings and tail being contaminated.

In my *Second Interim Report*, dealing with aircraft ground de-icing and related flight safety issues, I noted, however, that several senior airline pilots gave evidence that it is difficult, indeed impossible in some aircraft, for a pilot-in-command to determine from inside the aircraft whether the wing and the tail surfaces are clean at the time takeoff clearance is received. Darkness, precipitation, dirty or crazed windows, physical distance limitations, and aircraft design can all influence the ability of a flight crew member to observe accurately from the flight deck or the cabin the condition of the aircraft's lifting and control surfaces.

Similarly, the upper surfaces of the wings and tail of large aircraft are impossible to see from the outside without the use of elevated structures such as ladders, ground vehicles, and cherry-pickers. Although the upper surfaces of the wings can be seen to a degree from inside the aircraft, one still cannot see the upper surfaces of the horizontal stabilizer, particularly in "T-tailed" configured aircraft such as the DC-9, B727, F-28, and F-100. The distance from the windows to the ends of the wings also makes it difficult to discern detail. As well, to look out of the windows a pilot would have to leave the flight deck – obviously an undesirable activity, especially while waiting for takeoff.

Similarly, without elevated devices one cannot see from the outside the upper surfaces of the wings and the horizontal stabilizer on high-wing aircraft such as the Dash-8, ATR42, or BAe 146, and, because the windows are below the level of the wings, it is impossible to see such surfaces from inside these aircraft.

A number of expert witnesses were asked to give their views on means to allow flight crews to assess the condition of the outside of the

aircraft, in particular the upper surfaces of the wings and tail, without the use of outside personnel or of equipment external to the aircraft. The need for flight crews to observe the upper surfaces of wings and fuselages is not a recent idea. Mr Murray Morgan, a research pilot with NAE at NRC, drew on his experience as a pilot in the Royal Air Force. A former pilot of the large British delta-winged Vulcan "V" bomber, he stated that it had a retractable periscope installed in the roof of the aircraft. Mr Morgan explained that the crew was able to use this articulating periscope to observe the various upper surfaces of the aircraft.

Mr Gary Wagner, an Air Canada pilot and an aeronautical engineer, in testimony suggested that research be conducted into sensory equipment for detecting contamination. Mr Wagner also suggested that a video camera could be used for looking for ice (contamination) and for assessing the outside state of the aircraft, including the flaps.

Mr Eugene Hill, the manager of certification development of Boeing Aircraft's Renton division, in testimony suggested that, as an alternative to a person on a cherry-picker at the end of the runway giving an assessment to the pilot, a video camera mounted in the aircraft could be used to assess the outside of the aircraft. Mr Hill suggested that a closed-circuit television system including a camera with a telescopic lens and a spotlight would be appropriate for inspecting both the wings and the tail of the aircraft.

Mr Jack Lampe, the manager of cargo services and the de-icing commissioner for United Airlines out of O'Hare Airport in Chicago, provided this Commission with informational material from the Vibro-Meter Corporation with respect to a wing ice-detection system for aircraft. The system consists of a sensing device, about the size of a quarter, located on the wing. It has a conduit that goes from the sensing device through the fuel cell and into the fuselage to a black box that is hard-wired to a meter in the cockpit. The sensor detects when ice is adhering to it and activates a display in the cockpit.

Mr Lampe testified that McDonnell Douglas had dedicated an aircraft for the testing of this system. The company spent 22 days in Alaska, testing under various conditions, and agreed that this ice-detection system is the acceptable candidate to address the clear-ice problem on the MD-80 airplane. Mr Lampe, who stated that McDonnell Douglas intended to outfit all new MD-80 productions after mid-1991 with the unit, said that a retrofit kit would be available for installation on all existing MD-80s. The kit was being marketed at that time, principally by McDonnell Douglas, to address the clear-ice problem on the MD-80 aircraft.

Speaking as a United Airlines manager, Mr Lampe stated:

> A. It's something we're going to specify on any new airplanes that we buy, and we expect to retrofit existing airplanes with it after Boeing approves its installation.
>
> ... I think it's the only sane way, perhaps, to address inspection prior to takeoff, with the exception, perhaps, of a camera that might be mounted, which would give you some visibility of your leading edges.
>
> We've done some experimentation with that using existing cameras that we have on buses, for example, that operate quite well in low light to see if that might offer some surveillance to the cockpit so they could make a better call on whether they have contamination on the wing or whether they don't.
>
> (Transcript, vol. 82, pp. 85–86)

There is merit to all these approaches. Without well-developed procedures and adequate facilities, it is impractical and potentially dangerous to inspect externally an aircraft near the end of the runway prior to takeoff. I comment on this subject to bring to the attention of those in the aviation industry the fact that there are alternatives to the problems of external aircraft inspection.

Findings

- While the aircraft C-FONF was on the ground at Dryden on March 10, 1989, heat conduction into the wing fuel tanks (the cold-soaking phenomenon) permitted the lower portion of the water in the wet snow layer that accumulated on the wings to freeze, while leaving the upper portion in a partially liquid state. It is probable that the freezing of the water in the lower portion of this snow layer would have left a rough interface between the lower and upper portions of the precipitation layer on the wings.

- As the aircraft rolled down the runway during takeoff, pressure variations outside the wing boundary layer and the aerodynamic forces of air flowing over the wings probably forced the remaining water in the upper portion of the precipitation layer to drain away, carrying with it some of the slush, wet snow, and ice, and leaving behind a rough ice surface on the wings. This condition would have significantly degraded the aerodynamic performance of the aircraft.

- In addition, it is probable that snowflakes that were in the path of the aircraft wings during the takeoff roll stuck to the leading edge of the wings, in a band extending from approximately 3 per cent to about 19 per cent of the wing chord, thereby contributing to the degradation of the aerodynamic performance of the aircraft.

- During the takeoff of aircraft C-FONF from the Dryden airport, the wings of the aircraft were contaminated to a critical level, resulting in the degradation of the aircraft's aerodynamic performance by reducing its lifting capability and increasing the drag on the aircraft to the extent that, as the aircraft climbed out of ground effect, the performance loss caused the aircraft to descend and crash.

- During the takeoff run of aircraft C-FONF at the Dryden airport, slush thrown up from the runway probably did not enter the engines.

- If, during the takeoff run of C-FONF at the Dryden airport, contamination from the wings of the aircraft entered the engines, the contamination did not cause either a failure of the engine(s) or a reduction in thrust sufficient to tangibly affect the takeoff performance of the aircraft.

- Although there was some evidence of denting and chipped paint on the leading edges of the wings of aircraft C-FONF, neither of these factors contributed appreciably to the performance degradation of the aircraft during its takeoff from the Dryden airport, excepting that they may have been a minor factor in the amount of contaminant that remained on the wing.

- Wing anti-ice air leakage, such that it would cause control difficulties, was not a factor during the takeoff of C-FONF from the Dryden airport.

- Wing contamination is equally dangerous on jet-powered aircraft and propeller-powered aircraft.

- Wing contamination is equally dangerous on hard-wing aircraft and aircraft with wing leading-edge lift devices.

- The draft F-28 Operations Manual submitted by Air Ontario to Transport Canada did not contain a takeoff limitation and correction chart for contaminated runways (otherwise referred to as slush correction charts).

- Some Air Ontario F-28 pilots used the USAir F-28 Operations Manual while others used the Piedmont F-28 Operations Manual, both of which contained a takeoff limitation and correction chart (labelled for guidance only) that was considerably more restrictive than the chart and graph contained in the Fokker F-28 Flight Handbook (Aircraft Flight Manual), which was also available to F-28 pilots.

- Air Ontario had no policy in place to guide its F-28 pilots as to which slush correction charts were to be used by them for takeoff on a contaminated runway, and there was no consensus among the F-28 pilots as to which charts should be used, a highly unsatisfactory situation.

- The takeoff limitation and correction chart and graph contained in the Fokker F-28 Aircraft Flight Manual available to Air Ontario F-28 pilots was time consuming, and difficult and impractical to use in the cockpit of the aircraft.

- Had the pilots of flight 1363 followed the guidelines contained in the Piedmont/USAir takeoff limitation and correction charts at Dryden, they would have been restricted from taking off unless the runway had first been cleaned of contamination or the aircraft weight had been reduced to 54,300 lbs for takeoff. (The aircraft's actual weight at takeoff was estimated to be 64,440 lbs, just under the limit allowed by the Fokker chart.)

- Had the pilots of flight 1363 used the chart and graph contained in the Fokker F-28 Aircraft Flight Manual, the takeoff at Dryden on March 10, 1989, would have been permitted.

- Approval of slush correction charts is not presently a requirement of Canadian, Dutch, or United States regulatory bodies.

- A lack of certified data regarding aircraft takeoff performance requirements on contaminated runways makes it impossible to calculate whether the aircraft could have been stopped on the runway had an engine failure occurred at or prior to V_1.

- Neither United States FAA regulations nor Canadian Air Regulations and Air Navigation Orders address the issue of aircraft performance on takeoff from contaminated runways.

- Transport Canada and the Transportation Safety Board of Canada, and its predecessor CASB, have been aware of the lack of certified data regarding aircraft performance requirements on contaminated runways for a considerable period of time.

- Because of the absence of regulations with regard to the determination of aircraft performance requirements when operating aircraft from slippery or contaminated runways, the degree of risk that an aircraft's passengers and crew members are exposed to when the aircraft takes

off from a slippery or contaminated runway is different from that when the aircraft takes off from the same dry runway.

- Initiatives already taken by regulatory bodies, including Transport Canada, with regard to the determination and provision of guidelines to aircraft operators for operations from contaminated runways, will, if promulgated, improve passenger and crew safety.

- Air Ontario F-28 pilots had access to numerous cautions, warnings, and instructions not to take off unless all of the aircraft lifting surfaces were completely clear of ice or snow.

- In general, personnel involved in the aviation industry are not sufficiently aware of the nature and effects of wing contamination.

- In general, pilots are not sufficiently aware of the effects of cold soaking of fuel in relation to precipitation and frost adhering to the wing surfaces, and the conditions that lead to this phenomenon.

RECOMMENDATIONS

It is recommended:

MCR 40 That Transport Canada ensure that all operations personnel involved in air carrier operations, including managers, operations officers, maintenance personnel, and pilots, be made fully aware of the nature and the danger of wing contamination on both jet- and propeller-driven aircraft.

MCR 41 That Transport Canada ensure that all personnel involved in air carrier operations, including managers, operations officers, maintenance personnel, and pilots, have, and be able to demonstrate, a thorough understanding of all aspects of wing contamination, including its formation, removal, and prevention, and its effects on the aerodynamics of aircraft, with particular emphasis on the insidious nature of the "cold-soaking" phenomenon.

MCR 42 That pilots be informed in writing by Transport Canada how the application of non–standard handling techniques, as described in the "Flight Dynamics" report prepared for this

Commission and included in the Final Report as technical appendix 4; as described in the Fokker F-28 Flight Handbook; and as described in testimony by expert witnesses, may assist a pilot to deal with an abnormal or emergency situation discovered during takeoff. It is stressed that this Commission does not advocate the use of non–standard handling techniques to operate aircraft in adverse weather conditions as an alternative to the proper preparation of the aircraft for flight.

MCR 43 That Transport Canada require that aircraft flight manuals and related aircraft operating manuals contain approved guidance material for supplementary operating procedures, including performance information for operating on wet and contaminated runways.

MCR 44 That Transport Canada, in cooperation with aircraft manufacturers and operators, expedite the search for a technically accurate means of defining runway surface conditions and their effects on aircraft performance.

MCR 45 That Transport Canada require air carriers to provide adequate training to flight crews with respect to the effects of contaminated runways on the performance of aircraft in the context of landings, takeoffs, and rejected takeoffs.

MCR 46 That Transport Canada, in cooperation with aircraft manufacturers and operators, expedite the search for an equitable and practical means of requiring operators to adhere to balanced field criteria when operating on wet or contaminated runways.

MCR 47 That Transport Canada, in cooperation with airport operators, expedite the search for more efficient methods of ensuring that runways are maintained free of contaminants that affect the takeoff performance of aircraft.

MCR 48 That Transport Canada participate in and encourage research concerning devices that can allow pilots to assess the external state of the aircraft from within the flight deck. In addition to assisting pilots in assessing possible contamination of the aircraft, such devices would assist pilots in assessing any mechanical or technical problems on the exterior of the aircraft.

FINAL REPORT

TECHNICAL APPENDICES

1 Occurrence No. 825-89-C0048: Structures/Site Survey Group Report LP 38/89: Accident: Fokker F28, Mk 1000, Registration C-FONF, 10 March 1989
Canadian Aviation Safety Board Investigation Team

2 Fokker Aircraft B.V. Amsterdam, Fokker Aerodynamics, Report No. L-28-222: Note on the Aircraft Characteristics as Affected by Frost, Ice or Freezing Rain Deposits on Snow

3 Fokker Aircraft B.V. Amsterdam, Report No. VS-28-25: Flight Simulator Investigation into the Take-off Performance Effects of Slush on the Runway and Ice on the Wings of a Fokker 100

4 A Report on the Flight Dynamics of the Fokker Mk 1000 as They Pertain to the Accident at Dryden, Ontario, March 1989
J.M. Morgan, G.A. Wagner, R.H. Wickens

5 Wind Tunnel Investigation of a Wing-Propeller Model Performance Degradation due to Distributed Upper-Surface Roughness and Leading Edge Shape Modification
R.H. Wickens and V.D. Nguyen

6 Freezing Precipitation on Lifting Surfaces
Myron M. Oleskiw

7 Human Factors Aspects of the Air Ontario Crash at Dryden, Ontario: Analysis and Recommendations to the Commission of Inquiry
Robert L. Helmreich

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Commission d'enquête
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avion d'Air Ontario
à Dryden (Ontario)